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October 12, 1921

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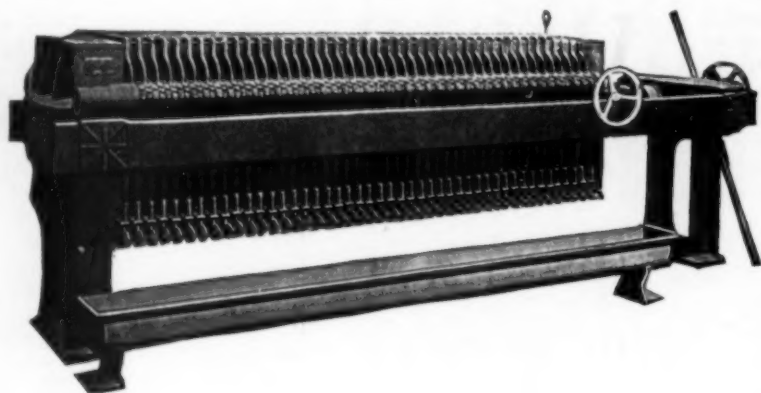
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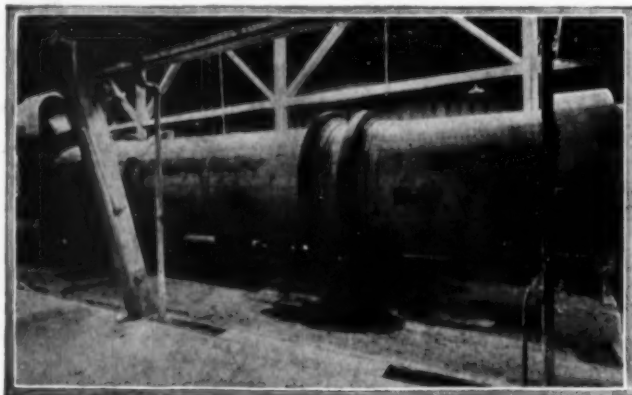
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How May Research Be Fostered?

A PLEA for a restricted use of the word "research" was made in these columns not long ago, using as a basis DR. HYDE's admirable outline of investigative work in science and engineering. Doubtless many who read those words agreed with DR. HYDE that the word "research," meaning a diligent and critical investigation in seeking facts or principles, clearly includes the five items in his classification, and would hold the editorial writer guilty of overdrawing a picture merely to emphasize his point of view. They would be inclined to use the word research as a generic term, modified by descriptive adjectives when necessary.

However that may be, undoubtedly all will agree that the unqualified word research or the phrase "pure scientific research" accurately describes patient searching in nature for evidences of hitherto unknown phenomena, and that such researches are of the utmost value in furnishing the fundamental basis of scientific and engineering progress. All will agree that too few qualified men are now engaged in such work, and the problem of instituting and stimulating research has been argued at length.

One result of this discussion is the conclusion that research ("pure scientific research," if you must, to be precise) can best be done in the future where it has always been done in the past: in universities or in endowed laboratories. Investigators in these institutions do not need to worry whether the things they are bringing to light can be capitalized immediately at a satisfactory profit. The highest type of university professor, as a matter of fact, is continually urged to extend the limits of his knowledge, not only because he must do so in order to fulfill his mission as an instructor, but because he realizes that his science is a growing thing, and he is the husbandman.

This urge from within is the researcher's motive power. Researches, in fact, cannot be directed. Imagine EUCLID examining his calendar after breakfast to find that this day he was to square the circle! Or that LIVINGSTON, in the trackless jungle, could be directed to discover Victoria Falls!

Undoubtedly, the researcher must be free! Various agencies which are now bestirring themselves to stimulate research would do well to bear this thought in mind. Acting on it they can do the most good. Perhaps they can see to it that the research professor receives a salary which will enable him to live without grinding economy in the dignified manner the importance of his work warrants, and permit him to visit freely at other institutions where interesting work is in progress. Relieve him of petty administrative detail. Then go away and leave him alone! For the true researcher has the same spirit as DAVY CROCKETT; he will move on as soon as he can see his neighbor's smoke.

Finding the Effect of American Valuation

MR. FORDNEY'S tariff has retired to the chambers of the Senate Finance Committee and the orders are that it is not to be disturbed—at least during the present session of Congress. Tariff problems have for the moment given way to discussions, discussions, discussions on taxation and unemployment. But we are reminded occasionally that the important policy of American valuation is still in abeyance, notwithstanding that it is the framework upon which the entire tariff must be built.

A few months ago a small group of prominent manufacturers met at the Chemists' Club of this city and organized the American Valuation Association, which has since been carrying on a vigorous campaign in favor of this change in our methods of assessing ad valorem duties. The press has been flooded with arguments and propaganda for its adoption and meetings of manufacturers have been held all over the country. In the meantime associations of importers, some of the large department stores and other tradesmen have been equally active in opposing the measure. It is obvious that this important issue must not be decided by either of these agencies nor by a Congress supplied only with partisan information obtained from these selfish sources.

American valuation of imports is generally referred to as an untried experiment, the effect of which can be studied only after the principle is adopted. We seem to lose sight of the fact that the true effect is susceptible of determination in advance. The importers' invoices in the Custom House and the manufacturers' sales records contain data which will show exactly what would have been the results had such a plan been in operation last week, last year or ten years ago.

Recognizing the good that such an investigation might accomplish, Congress recently placed a substantial appropriation at the joint disposal of the Treasury Department and the Tariff Commission and instructed these agencies to make an exhaustive study of American valuation. Formal announcement has not been made as to the complete plans for this co-operative work, but a director has been appointed and at least one conference has been held with manufacturers and representatives of the trade.

We had hoped that the investigation might be of a non-political nature and we were therefore surprised to learn that the directorship has been conferred on a former secretary of the Republican National Committee. However, he may have been selected for his appreciation of scientific tariff making, so we still believe the investigation can be made worth while. Information of unusual industrial significance can be obtained from a comprehensive study and a judicious sifting of facts and figures. American valuation holds much at stake for the chemical industry and we are justified in insisting that the plan be put to a thorough and impartial test.

Electrochemists At Lake Placid

ANIMATED discussion marked the technical sessions of the Lake Placid meeting of the American Electrochemical Society, a complete report of which will be found elsewhere in this issue. Organic electrochemistry was represented on the program by several papers, but the most interesting contributions to the subject came out in discussion following Mr. LIDBURY's assertion that the topic was of little or no practical importance. This brought several members to the defense with brief statements of what is being done industrially with organic electrochemistry. Unfortunately the speakers could not go into detail regarding their work, but enough was said to show that organic electrochemical industry is an accomplished fact in this country and that we can confidently look forward to further development and specific applications that will be made public in due time.

A valuable contribution was made to the old but ever new subject of corrosion by J. NEWTON FRIEND, whose theory, while not pretending to finality or completeness, aids in explaining some phenomena hitherto unexplained or but partly understood. In the symposium on electrodeposition Mr. BLUM's papers were of first importance, showing the influence of the crystal structure of the base metal on the nature of the deposit of the plated metal. Important conclusions were also presented on the effect of addition agents and their relation to current density. In the symposium on the electric furnace in non-ferrous metallurgy there was a natural, though not wholly unavoidable, tendency toward commercialism that should not encroach too far on the scientific and engineering aspects of the subject. A judicious mixture of papers by furnace users as well as by manufacturers will avoid giving such a program too much of the trade aspect. Mr. ST. JOHN's paper can be commended as a fair and impartial exposition of the influence of different types of electric furnace on non-ferrous metallurgy.

The meeting was held amid delightful surroundings that offered opportunity for sport and recreation between technical sessions. Golf, mountain climbing and lake bathing for the hardy ones were among the daily diversions which added to the regular activities left few idle hours. Nor were indoor sports entirely lacking. The club menus printed in Mr. DEWEY's simpler spelling added zest to the game of deciphering the code in order to get enough to eat. Careful inquiry revealed no converts to the new orthography, and some were found who said that *apl py* and *cofi* didn't even taste like mother's justly famous brands.

Baltimore has been selected for the spring meeting and plans are already under consideration by energetic local members. The earlier convention of the American Institute of Chemical Engineers in the same city in December should in no way detract from the success of the electrochemical meeting. Industrial plants in ample number and variety will be open to inspection and the meeting will take on a character quite different from the last two, which have been held at resorts wholly lacking in industrial attractions. Each type of meeting place has its merits and demerits, and while some would always prefer the industrial city, we think the Society gains by occasionally selecting the pleasure resort. Much depends on the appropriateness of the technical program—a point that the directors are keeping in mind.

Railroad Rates And Business Activity

IT IS DOUBTFUL whether any really good purpose is served by the talk now so prevalent that recovery in business activity is prevented or at least greatly retarded because of the failure of railroads to reduce their freight rates. That shippers should discuss this matter with railroad officials is eminently proper, but talking to the general public is another thing altogether. The public has absolutely no voice in the matter. One may admit that it was representatives of the public who passed the transportation act, but the act more than justifies the present rates, for it authorized the Interstate Commerce Commission to set rates calculated to yield the railroads 6 per cent. Under the rates thus fixed the railroad earnings during the first six months of this year were at an average rate of 1.8 per cent a year, while in July the earnings were at the rate of 4.5 per cent. There is a large deficiency, and the commission cannot order reductions, which are feasible only by voluntary act of railroad officials.

We are not proposing that facts be concealed from the public, but when the public is told that failure to reduce rates is responsible for any prolongation of the business depression a one-sided view if not an entirely erroneous view is promoted. The public is not equally well informed as to the revenue needs of the railroads, in view of earnings reports through July, nor is it given adequate arguments that reductions in rates would greatly stimulate business.

For several months past much that has been printed and much that has been said in private conversation has been in emphasis of the bad features of the business situation, while the good features have been slurred over. A year ago it was being said that we needed harder and more efficient work, while today much is said of the men who are out of employment, some of them being idle because they refuse to accept reasonable wages, and practically nothing is said of the hard and efficient work of those who are in employment, although a fair count might show the latter to outnumber the former six or eight to one. If all who work, not simply those who are called artisans or common laborers, were reckoned with, the proportion would probably be eight or ten to one.

It is considered a debatable question whether majorities are always wrong or only usually wrong. It is a fairly safe working rule that if a remedy for a state of affairs is generally urged it is a false remedy. As suggesting the correctness of this statement one can recall various periods before the war when the talk throughout business circles was that the Interstate Commerce Commission should permit the railroads to advance freight rates so that the railroads would buy things and make business good. Now many men—and quite possibly the same men—want rates reduced even though the railroads have not been making their bare expenses.

There is one subject, on the other hand, in which publicity would do a great deal of good, and that is the matter of wage rates and working conditions in the building trades. Some of their peculiar doings have been aired, but the subject will stand much more publicity, and such publicity would be a vastly greater help toward improving business and industrial conditions than saying to the public that it cannot expect improvement in business until by some chance freight rates are reduced.

And Now the Question:**"What Is the Chemical Engineer?"**

THAT puzzling enigma, What is a chemist? remains unanswered, but in the meantime some badly needed light is being shed on the more complex problem of defining the status of the chemical engineer. Dr. BAEKELAND in his recent address before the International Meeting of the chemical societies stressed the importance of bringing the public to a complete realization of the duties of both the chemist and the chemical engineer and of their contribution to our modern civilization. In referring to the confusion existing in the mind of the layman, he declared: "What appears even less obvious is the relation of the chemist to the chemical engineer. It is less known that a man may be a scientific star of the first caliber and yet incapable of utilizing his science in the industries or of applying it in the many other ramifications of the economics of our civilization."

We believe that one of the reasons for the lack of a definite understanding of the functions of the chemical engineer is the failure of some of our colleges and universities to recognize chemical engineering as a branch of the engineering profession. They do not place the subject on a parity with civil, mechanical and electrical engineering, but relegate it to a position of little importance either by lumping it in with their chemistry courses or otherwise hiding it away in their colleges of arts or sciences. Only a few of the more forward-looking institutions have completely divorced their curricula in chemistry and chemical engineering and have wisely placed the latter courses in their engineering colleges. In the survey of chemical engineering education made by a committee of the American Institute of Chemical Engineers and summarized in our issue of June 15, the reader was impressed by the wide variance of opinion as to what constitutes chemical engineering. This was evidenced by the fact that in the seventy-eight institutions considered at that time about 225 different studies were being taught to chemical engineering students and in no two institutions were the chemical engineering courses identical or even substantially alike. Permitting a certain amount of specializing is undoubtedly a wise policy, and the student, under proper supervision and within reasonable limits, should be allowed to choose his own line of development. It is obvious, though, that much standardizing in our chemical engineering education is necessary, and this can best be promoted by a definite knowledge of what is required of the chemical engineer and in what fields his energies are to be expended. The failure to equip the graduate with sufficient knowledge to cope with engineering problems or the overdevelopment of the engineering viewpoint without a thorough grounding in the fundamentals of chemistry are mistakes which some of our institutions have made and are continuing to make. It is not out of place, therefore, to weigh carefully the words of one who has been successful in the thoroughly practical phases of chemical engineering. We continue to quote from Dr. BAEKELAND's address: "The chemist, confined by the walls of his classroom, his laboratory or his library, sometimes fails to exercise sufficiently his sense of proportion. He is inclined to concentrate too much on only the part of the subject with which he is confronted. He is apt to neglect other considerations, which, although unimportant from a scientific viewpoint, frequently carry with them the very elements of success or failure in practical applica-

tions. Nor are the engineers, as a class, free from being carried away by a one-sided point of view, although it is admitted that their way of grappling with a problem is more along quantitative considerations. The ways of thinking and acting of the chemist and of the chemical engineer are often along decidedly different points of view, yet if these can be compromised, or harmonized, they bring forth good engineering."

Unemployment**Among Engineers**

CURIOSLY enough, one overoptimistic person expressed the view at the President's conference that there was no unusual amount of unemployment at the present time. How fortunate it would be if a meeting called to find work for idle hands to do should discover its job already done, simply because there was no idleness!

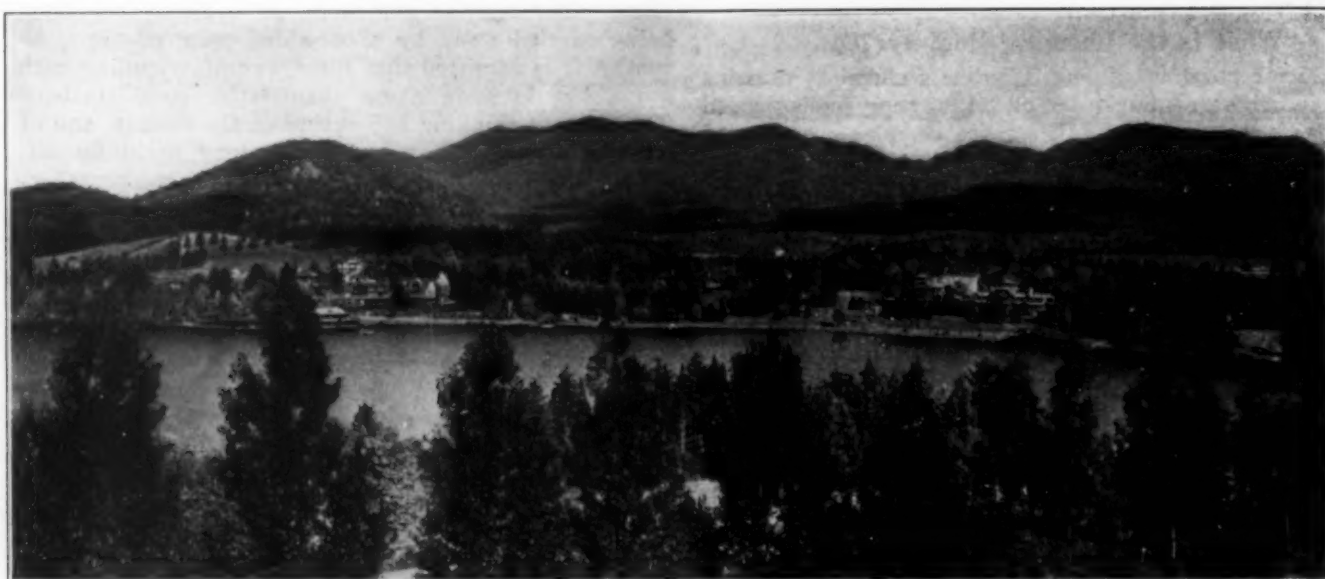
Engineers, members of what is now a "feast or famine" profession, generally would agree with the more pessimistic view—that jobs are few and far between. Chemists and metallurgists particularly have been through lean months. Many large firms have been slashing right and left into their appropriations for investigative work, forgetting their war-time experiences, when they clamored for competent technical men to show them how to produce an acceptable article. Some have even gone so far as to curtail their expenditures for publicity.

It is all very well for the detached philosopher to remark, "Oh, very well, executives who regard research as a luxury would not profit by the findings of their laboratory anyway." But true though that may be, it does not make it any easier for the idle technical man to locate new work worthy of his talents, or comfort the engineer who is earning bread and butter as an analyst or a "man at the fire."

As we see it, the big problem of seasonal employment of engineers will not be solved until the public realizes that the increasing vigilance of engineering control is necessary in order that any manufactured product can reach the ultimate consumer with the greatest perfection and the least waste en route—that is to say, until the people of the United States know that the engineer is essential to a quality product at a reasonable price.

From this standpoint it is apparent that some time will elapse before the engineer will come into his own, and many faint-hearted and unfit will take an easier way. But this is his undoubted destiny, and the rewards to the strong will be great.

Many agencies are hastening the day of public appreciation of the engineer: The Federated American Engineering Societies has its greatest opportunity for usefulness in this very direction; the technical press has never been more influential nor more representative of the dignified calling of its subscribers; but first and foremost, the individual engineer is and must be the most powerful exponent of his own worth. No matter how hard hit he may be by the present industrial depression, he can show his neighbors and employers that he is by a wide margin a better man than another of no technical or scientific training. Such a man, of course, is a good citizen and lends his aid in every movement to improve living conditions and uphold the ideals of our Government. Such a man, perhaps needs no admonition of ours, but in view of the many signs that the trough of depression has passed, he may be heartened to the long pull ahead by a cheery "God speed."



LAKE PLACID IN THE ADIRONDACKS, NEW YORK

Meeting of the American Electrochemical Society

Report of the Fortieth General Meeting Sept. 29 to Oct. 1, 1921—Papers on Corrosion and Electrolysis—Symposiums on Non-Ferrous Metallurgy and Electrodeposition—Meeting of the Board of Directors—Social Features

THE fortieth general meeting of the American Electrochemical Society was held Sept. 29 to Oct. 1, 1921, at the Lake Placid Club in the Adirondacks. Largely due to the untiring efforts of President Smith and William M. Corse the meeting was one of the most enjoyable and sociable ever held by the society. Seldom in the history of the society has there been such an opportunity for the forming and cementing of friendships. The beautiful surroundings and exhilarating air put every one in the best of moods and was conducive to sparkling wit and joyous laughter. Never before were so many electrochemists' wives in evidence.

The three mornings were devoted to the reading and discussion of papers. President Acheson Smith presided. On Thursday the two general themes introduced were corrosion and electrolysis; on Friday the symposium on non-ferrous electrometallurgy was held, and on Saturday the symposium on electrodeposition.

Papers on Corrosion

ALKALINE AND ALKALINE EARTH METALS IN CONNECTION WITH NON-FERROUS ALLOYS

The first paper of the Thursday, Sept. 29, session was by Charles Wickers of Buffalo on "Experiences With Alkaline and Alkaline Earth Metals in Connection With Non-Ferrous Alloys." The author reported on a number of experiments which tended to show that metallic sodium could not be used satisfactorily for deoxidizing copper but that when added to molten copper or bronze in the form of an alloy such as sodium-tin, it appears to produce an alloy of superior torsional strength. Of the alkaline earth metals, calcium is valueless in producing solid copper castings, nor has it any value in bronze. As a deoxidizing agent in copper,

calcium is at its best when combined with an acid element such as silicon, and this combination is improved by a third element. This latter combination is being used with success for the production of copper castings possessing very high electrical conductivity. Barium and strontium appear slightly more promising than calcium, but he stated that a large amount of foundry research work is necessary before their actual value is known.

This paper was of particular interest to the electrical engineers present and it was pointed out by C. G. Schluederberg of the Westinghouse company and John A. Seede of the General Electric Co. that high electrical conductivity was absolutely essential if the copper castings were to be used in electrical apparatus. It was suggested that castings deoxidized by Vickers' new alloy be compared with Weintraub's castings purified by boron suboxide. Colin G. Fink of South Yonkers emphasized the importance, when selecting a deoxidizer for copper, of taking into account the melting points of the products formed. If calcium is used, the calcium compounds resulting must preferably be fluid and readily rise to the surface of the molten copper. Prof. Joseph W. Richards added that it was equally important to have the product agglomerate rapidly.

ELECTROLYTICALLY PRODUCED CALCIUM-BARIUM-LEAD ALLOYS COMPRISING FRARY METAL

William A. Cowan, L. D. Simpkins and G. O. Hiers contributed a paper on "Electrolytically Produced Calcium-Barium-Lead Alloys Comprising Frary Metal." They gave a detailed account of their study made at the research laboratories of the National Lead Co. on the development of Frary metal and of its production by electrodeposition from a low melting point mixture of cal-

cium and barium chlorides over a bath of molten lead as cathode.¹

In the discussion, Charles H. Proctor of the Roessler & Hasslacher Chemical Co. referred to his experience in recasting 12 per cent antimonial lead and the difficulty of preventing dross from segregating in spots. Would the addition of small percentages of Frary metal to the melt eliminate or reduce this evil? Would it be better than the use of the green hickory poles? Prof. Richards called attention to the very low efficiency of the Frary metal cells or pots operating at 2,000 amperes and 10 volts.

ELECTROLYTIC CORROSION OF THALLIUM-LEAD ALLOYS

Tests made on a series of lead alloys were outlined in a paper on "Electrolytic Corrosion of Thallium-Lead Alloys" by Colin G. Fink and Charles H. Eldridge of South Yonkers. The alloys were cast into anodes and submitted to electrolytic corrosion in an acid copper sulphate electrolyte containing both hydrochloric and nitric acids. Thallium is one of the few metals whose lower oxide is more stable than the higher oxide; another distinctive feature of thallium is that when alloyed with lead the fusion curve rises decidedly above that of either constituent, whereas the melting point of most other binary lead alloys is lower than that of at least one of the constituents. A minimum anodic corrosion loss of 1.2 lb. per 100 lb. of copper deposited resulted with a lead anode containing 10 per cent Tl and 20 per cent Sn,² as compared with 65 lb. loss for ordinary lead. In general it was found that lead alloys with high melting points are more resistant to corrosion. The low corrosion losses are largely due to a very adherent protective film formed during electrolysis.

Discussing the thallium-lead alloys, Henry Howard of Cleveland referred to the possible substitution of one or the other of these for ordinary lead in the construction of sulphuric acid chambers. George B. Hogaboom of the Scovill Manufacturing Co. called attention to the need of a high melting point solder that would withstand enameling oven temperatures. In reply, it was stated that lead-thallium alloys readily dissolve copper and silver and it would therefore seem that a lead-thallium or a lead-thallium-tin alloy would answer the high-temperature requirements.

A NEW THEORY OF THE CORROSION OF IRON

Dr. J. Newton Friend of Birmingham, England, has made an exhaustive study of the corrosion of commercially pure iron, as a result of which he has developed an entirely new interpretation of the mechanism of corrosion. According to this theory, iron in coming into contact with liquid water in the presence of air or oxygen slowly oxidizes to ferrous hydroxide. This, however, is produced in the colloidal condition—a state in which it is usual for many substances to be particularly reactive. The ferrous hydroxide hydrosol now undergoes oxidation to a higher hydroxide hydrosol, ferric hydroxide sol being produced in the most favorable circumstances. This higher hydrosol is now alternately reduced in contact with the iron and oxidized again by atmospheric oxygen, thus catalytically accelerating the oxidation of the metal. When the sol flocculates or

precipitates out, it yields rust. If this theory is correct, it will be clear that all processes, whether physical or chemical, which effect the precipitation of positive colloids should tend to retard corrosion, and, on the other hand, those which tend toward the stabilization of positive colloids will enhance corrosion. These conclusions have been substantiated by the results of numerous experiments.

The paper was discussed at length by Dr. Fink; in concluding his remarks he suggested that Friend's theory ought to be borne in mind when studying the corrosion of metals other than iron. W. E. Hughes in writing from London referred to a recent experimental confirmation of Friend's theory by A. Ackermann.³ Ackermann observed under the microscope the formation of ferric hydroxide and that this colloidal substance is the first product of a series of reactions which finally result in rust. Hughes closes his letter with the remark that the fundamental problem, however, is still unsolved, since Dr. Friend does not tell us what the forces are that operate to cause the conjunction of the iron atoms and hydroxyl groups of which the hydrosol is composed. "What forces operate to produce the colloid? In the answer to this question lies the statement of the cause of the corrosion of iron."

RUST PREVENTION BY SLUSHING

The practical side of the problem of the corrosion of iron was emphasized in the paper on "Rust Prevention by Slushing," presented by Dr. Haakon Styri. He described the results of a series of investigations made under his direction at the S.K.F. research laboratory in Philadelphia. The conclusion arrived at was that a prerequisite for protection against rust by greases is a thorough cleaning of the steel parts by an aqueous solution, preferably by an oil emulsion which leaves a thin oil film for short time protection. Such oil emulsion is also a very good grinding liquid. It protects from rust and gives a fine finish.

Dr. Styri's paper was discussed by President Acheson Smith, Charles Proctor and others. Dr. William Blum of the Bureau of Standards said that the Government has difficulties in preventing the corrosion of various munitions in storage, but has found that simple slushing compounds would satisfactorily combat corrosion. Prof. Richards referred to a Japanese sword in his possession which had been slushed with oil containing very finely divided lead. After years of exposure there is no visible corrosion.

Papers on Electrolysis

TRANSFORMER OIL SLUDGE

Three general types of transformer oil sludges were discussed by C. J. Rodman of the Westinghouse Research Laboratories. The first, or asphaltic, sludge is produced by the oxidizing action on poor transformer oils such as contain unsaturated compounds, water, small resinous bodies and certain accelerators or catalysts. Examination of the sludge showed that it consisted largely of hydrocarbons of high molecular weight containing oxygen. Thus it may be considered as a combination of oxyasphaltic compounds. It is the most general form of sludge. It collects upon the active parts of the transformer, thus preventing the dissipation of heat. If moisture-free its electrical properties are fairly good. The second type, or soap sludge, is a good

¹This paper will be printed in a subsequent issue of CHEMICAL & METALLURGICAL ENGINEERING.
²U. S. Pat. 1,384,056, July 12, 1921, CHEM. & MET. ENG., vol. 25, No. 14, p. 668, Oct. 5, 1921.

³Kolloid Z., vol. 28, p. 270 (1921).

moisture and oxygen carrier. It forms slowly and it is difficult to remove entirely by filtration. The third type, or the carbon sludge, is due to electrical breakdown.

Commenting on Mr. Rodman's paper, W. S. Moody of Schenectady described a series of tests carried out at the General Electric plant which led to the conclusion that when the oil was exposed to air there was much sludging and in the absence of air there was practically none. Accordingly an auxiliary tank was connected to the transformers and all air excluded.

ELECTROLYSIS OF ORGANIC COMPOUNDS

Dr. Raymond Freas, of New Orleans, submitted a paper on "Factors Influencing the Electrolysis of Organic Compounds," in which he discussed the factors entering into electrolytic reduction and described a convenient experimental arrangement used in their study.

Dr. C. J. Thatcher of New York, who has been manufacturing large quantities of organic chemicals electrolytically for a number of years, called attention to the interesting fact that the product could be varied by changing the charge of the electrode from negative to positive or *vice versa*.

ELECTROLYTIC DISSOCIATION OF CYANAMIDE AND OF SOME OF ITS SALTS IN AQUEOUS SOLUTIONS

Prof. Naoto Kameyama of the Tokyo Imperial University forwarded a manuscript on "The Electrolytic Dissociation of Cyanamide and of Some of Its Salts in Aqueous Solutions." He found that sodium acid cyanide in aqueous solutions is hydrolyzed at 25 deg. C. to the extent of 4.5 to 12.9 per cent in the dilutions of 10 to 80 liters per gram mol, respectively. If this hydrolysis is prevented by an excess of cyanamide, dissociation occurs to almost the same extent as in the case of sodium formate. Under similar conditions unhydrolyzed calcium acid cyanamide dissociates to the same extent as magnesium formate or calcium nitrate. The primary dissociation constant of cyanamide, as an acid, at 25 deg. C., was found to be 5.42×10^{-11} ; the conductivity of the cyanamide anion being 54.4 at 25 deg. C.

ELECTROLYTIC OXIDATION OF THE LEUCO-BASE OF MALACHITE GREEN

Alexander Lowy and Elmer H. Haux gave an account of their experiments carried out at the University of Pittsburgh on "The Electrolytic Oxidation of the Leuco-Base of Malachite Green." They stated that it is usually oxidized on a commercial scale by a slight excess of the theoretical quantity of lead peroxide, which must be carefully prepared, and used in the form of a thin aqueous paste. The insoluble lead compounds are then filtered, the filtrate heated and the soluble lead salts precipitated with sodium sulphate. In order to ascertain the possibility of substituting electrical energy for chemical energy, forty-four experiments were carried out by the authors. The conclusions arrived at indicate the necessity of a catalyst, an elevated temperature for efficient oxidation, a low concentration of the leuco-base in the anolyte, and sulphuric acid as solvent and electrolyte. The highest dye yield was obtained with uranyl sulphate as catalyst, platinum cathode, and nichrome gauze anode in dilute sulphuric acid solution, at a temperature of 85 deg. C.

A very animated discussion ensued in which Messrs. Burwell, Lidbury, Thatcher, Fink, Howe and Lowy participated. Dr. Arthur W. Burwell of Chagrin Falls, Ohio, announced that the Reliance Aniline & Chemical

Co. at Poughkeepsie was producing commercially hydroquinone directly from benzene by electrochemical methods. He stated furthermore that the Western Reserve Chemical Co. of Cleveland had been making tons of phthalic anhydride for the past four years. Dr. Lowy added that since writing his paper new results have been obtained: The yield of malachite green has been as high as 67 per cent, as compared with 60 per cent by the older processes. He displayed samples of yarns that had been dyed by the "electric malachite" and had been tested at the du Pont laboratories. The color yield was up to 100 per cent strength; the solubility as good as that of ordinary malachite, in some cases even better. Experiments are now in progress on the electrolytic oxidation of dimethylaniline to dimethyl violet.

ELECTROLYTIC PRODUCTION OF SODIUM PERBORATE

Peder Chr. Alsgaard presented a paper on the "Electrolytic Production of Sodium Perborate," in which he embodied the results of his work at Cornell University. The chemical properties and industrial uses of sodium perborate were reviewed and a detailed account was given of the research work by Arndt and Valeur on its preparation by the electrolysis of a borax solution containing sodium carbonate. In order to develop the technical and commercial utilization of the electrolytic process, the experiments of Valeur were repeated on a large scale, and although certain difficulties were encountered, practically all of the earlier results were confirmed. From these experiments it was possible to furnish the facts and figures necessary for the technical design and calculation of the costs of production.

Commenting on Mr. Alsgaard's results, Prof. Richards reported that he had visited the electrochemical plant at Fredrikstad, Norway, this past summer and witnessed the introduction of the new Moltkehanzen perborate process. Mr. Alsgaard added that in this new process cyanide is used to prevent reduction of perborate by iron. Dr. F. A. Lidbury of Niagara Falls emphasized the importance of keeping the concentration of iron low in order to get good yields.

THE ELECTROLYTIC OXIDATION OF HYDROCHLORIC ACID TO PERCHLORIC ACID

Prof. H. M. Goodwin and Dr. E. C. Walker, 3rd, of the Massachusetts Institute of Technology have presented the results of their investigations on the best conditions under which hydrochloric acid may be electrolytically oxidized to perchloric acid. They studied the effect of concentration of acid, current density, duration of electrolysis and temperature of the yield.

GRAPHIC CONTROL OF ELECTROLYTIC PROCESSES

B. G. Worth of New York outlined briefly his method of "Graphic Control of Electrolytic Processes." It was found by research in a chlorate plant that the high yields for the particular type of cell, electrodes and other chemical and electrical features depended principally on the varying relations among three factors: two chemical factors which may be called A and B (representing concentrations of two compounds in question) and the third factor, the temperature, called T. It was calculated from the reactions that in order to get the best results a certain numerical relation must exist between A and B. A was incapable of direct control, being the result of establishment of equilibrium, but B

*The paper will be printed in full in a subsequent issue of this magazine.

was controllable by addition agents. Knowing *A*, it was possible to compute what *B* should be, which figure was called "Proper *B*" (*PB*). Accordingly a system was inaugurated by which the contents of each cell were analyzed daily and the results plotted by weeks. From the curves it was obvious that whenever the *B* advanced or receded beyond a certain point remedial measures had to be taken. In practice this was a simple matter, as it necessitated only a change in the rate of feeding addition agents. After a while it became possible to anticipate changes by extending the curve by extrapolation and then making proper changes 24 hours in advance, thereby forestalling what otherwise would have been a falling-off of efficiency.

Mr. Worth's paper was discussed by Dr. Schluederberg of Pittsburgh. He commented favorably upon the method and added that it is of particular value to the young electrochemist entering the employ of one of our large factories and desiring to familiarize himself with details in plant operation.

PROF. RICHARDS' TALK ON SCANDINAVIA

At the conclusion of the Thursday morning session Prof. Richards gave a very enjoyable talk on his recent experiences in Scandinavia and reported that the Söderberg electrode is rapidly displacing the older types. In Norway at one of the metallurgical plants the Söderberg is carrying 1,000 amp. At an electric steel plant a tilting Heroult furnace is equipped with Söderbergs which are fed in sections 2 m. long. There are no additional complications as compared with the older types of electrode. The capacity of the Heroult is 6 tons and the distance between metal and roof is about 1 meter. At another plant large aluminum-cased Söderbergs up to 18 in. square were just being tried out on the aluminum cells. The consumption of the electrode in the bauxite bath was very uniform, the ends of the electrodes remaining plane parallel.

Symposium on Non-Ferrous Electrometallurgy

INFLUENCE OF THE ELECTRIC FURNACE ON THE METALLURGY OF NON-FERROUS METALS

The opening paper of the symposium was "The Influence of the Electric Furnace on the Metallurgy of Non-Ferrous Metals," presented by H. M. St. John of the Detroit Electric Furnace Co., in which he gave a general review of the changes which the electric furnace is making in the non-ferrous metallurgical practice and showed that by using electric melting, products of higher quality are produced with less labor and wastage than when using fuel-fired furnaces.

The paper was enthusiastically received and a very lively discussion followed in which both furnace builders and furnace users participated.

RESISTANCE TYPE ELECTRIC FURNACE

T. F. Baily presented a paper on "The Resistance Type Electric Furnace in the Melting of Brass and Other Non-Ferrous Metals." He enumerated the points to be considered in the selection of an electric furnace and is of the opinion that, when taking into consideration the total cost per ton of merchantable castings or bars produced and the adaptability over a wide range of alloys, the resistance type of furnace comes more nearly filling all the requirements than any other type of furnaces.

H. M. St. John and H. W. Gillett of Ithaca, N. Y., took exception to some of the claims made by Baily.

John A. Seede of Schenectady advocated a more general application of electrode regulators. Dr. Fink referred to the melting of copper in the Baily furnace and Dr. Richards brought up the question whether the color of the metal had any effect on the speed with which the melting temperature is attained in a furnace where the heat is indirectly applied. St. John and Gillett maintained that at high temperatures the color of the metal has no effect on thermal efficiency. At low temperatures, however, as Mr. Seede reported, it was found that aluminum absorbed heat 7 per cent as fast as copper. Mr. Baily added that temperatures up to 1,850 deg. C. are practical in his furnace and that he had successfully melted 0.05 carbon steel.

ELECTRIC VS. FUEL-FIRED FURNACE PRACTICE

N. K. B. Patch of the Lumen Bearing Co. in his paper, "Comparison of Electric Furnace Practice With Fuel-Fired Furnace Practice," related his experiences with a Baily and a Detroit Rocking furnace as compared with fuel-fired furnaces. The outstanding advantage of the electric furnace is its cleanliness and comfortable working conditions. On the other hand, a fuel-fired furnace still has a decided advantage over the electric furnace in the consideration of first cost.

Mr. Patch's paper was commented upon by Messrs. Gillett, Richards, Howard, Lidbury and others. C. B. Gibson of Pittsburgh and George K. Elliott of Cincinnati contended that it was almost impossible to draw cost comparisons, the prices for fuel and electric power varying in different localities. Dr. Richards mentioned that during a recent visit to the Lumen Bearing Co.'s plant he noted with much satisfaction that the outside of the furnaces had been painted white. According to his experience, this bright outer surface increases the thermal efficiency by 10 per cent.

MODERN DEVELOPMENTS IN THE BRITISH BRASS INDUSTRY

Ernest A. Smith of the British Non-Ferrous Metals Research Association submitted a detailed exposition on the "Modern Developments in the British Brass Industry." There appears to be comparatively little scope in Great Britain for electric furnaces of large capacity such as the Ajax-Wyatt, Detroit Rocking, and the Baily, in which the bulk of the electric brass melting is done in America. These furnaces require large and expensive installation and must be operated continuously on one or at most two standard alloys before any material saving can be shown. These conditions do not apply to a large majority of the British works, many of which have only an average daily output of from 500 to 600 lb.

ELECTRIC SILVER SMELTING

One of the most interesting papers of the symposium and one which included a number of novel features was the paper by H. A. DeFries of New York on "Electric Silver Melting." Silver melting in the electric furnace eliminates high crucible cost and the necessity of an experienced melter, which are essential to gas- or oil-fired crucible practice. Distinction is made between pouring temperatures of bar silver (1,038 to 1,093 deg. C.) and of rolling mill and casting silver (1,293 to 1,304 deg. C.), when casting horizontal molds.⁵

Mr. DeFries' paper gave rise to lengthy discussions.

⁵For a description of the operating conditions for melting fine and sterling silver, melting outfit arrangement, cost and a comparison of the qualities of electric and crucible silver see *CHEM. & MET. ENG.*, Sept. 14, 1921, p. 507.

Mr. Hogaboom emphasized the importance of a high pouring temperature which can be so readily attained in the case of the electric furnace. Dr. E. F. Northrup of Trenton reported that over a million ounces of silver had been melted in his furnaces. In order to eliminate holes and flaws in the rolled sheets he has found it good practice to transfer the crucible from the electric furnace to an oil-fired furnace and permit the melt to soak for a time. Such metal when cast and rolled was free from flaws. In commenting upon the use of the iron block in the molten silver Dr. Fink said that after a number of heats the surface of the block showed very characteristic erosion marks, which would seem to prove that chemical reaction was taking place.*

ELECTRIC MELTING OF NICKEL SILVER

Prof. F. C. Thompson of Sheffield University, England, communicated a brief note on his experience on "The Electric Furnace Melting of Nickel Silver." The author's opinion is that the arc furnace is satisfactory only where all the constituents of the melt are non-volatile. When dealing with nickel silver this type of furnace ceases to be very useful as a result of the large volatilization of zinc around the electrodes. Experiments carried out in a small Kjellin induction furnace have not yielded results which possess much promise. Resistance furnaces would appear to be satisfactory. He then discussed the advantages of the use of such furnaces from the purely technical point of view—namely, reduction of the loss in zinc to less than 1 per cent, the occlusion of gases is minimized and a tougher alloy results owing to less carburization. He concluded by stating that where local conditions render it economically advisable the electric furnace of the external heating type possesses technical advantages, especially where large quantities of scrap require to be remelted.

Mr. St. John took exception to Prof. Thompson's conclusion that the resistance type of electric furnace is the only possibility for nickel silver, since he had confined himself to stationary furnaces.

ALUMINUM-COPPER ALLOYS

Robert J. Anderson, of the U. S. Bureau of Mines, contributed a paper on "Aluminum-Copper Alloys," which constitutes an exhaustive treatise on the manufacture, properties and uses of the commercial aluminum-copper alloys employed in the United States. The classification of these alloys is shown in Table I. When dealing with their corrosion he stated that the question of the corrosion of the light aluminum-copper alloys under various conditions of service has not yet been thoroughly investigated, although numerous isolated

tests of particular compositions have been made under many conditions, and that it would be of the greatest interest to obtain data with regard to the effect of various additive elements, in small percentages, upon the corrosion of the usual light aluminum-copper alloys.

ELECTRIC FURNACES OF THE MUFFLED ARC TYPE

H. A. Winne of the General Electric Co. presented a paper on "Recent Developments in Electric Furnaces of the Muffled Arc Type." A number of new types of muffled arc furnaces for melting brass, bronze and similar non-ferrous alloys and metals were described. The larger rectangular shell type furnace was compared with new designs for smaller units having capacities of 1,500 lb. or less per hour. Among the many advantages claimed for the muffled arc furnaces described by the author are that little space for heating elements is required, metal losses by volatilization are reduced, a neutral or reducing atmosphere is maintained, and load fluctuations are small. They are adaptable to intermittent operation; other features are accessibility of hearth, low electrode consumption and small expense of refractories.

REFRACTORIES FOR ELECTRIC FURNACES

The increasing importance in selecting the right refractories for electric furnaces was brought out in the following two papers:

Electric Furnace Purification of Zirkite.—J. C. Thompson of Cornell University reported the preliminary results of his investigation on the possibilities of electric furnace purification of zirkite. He found that 90 to 95 per cent of the silicon may be largely removed from siliceous zirkite ore by heating a mixture of ore and carbon to above 2,220 deg. C. in an electric furnace. The best results appear to be obtained by feeding into an arc furnace a mixture of ore and coke, the amount of carbon being approximately that required to transform only the silicon to the carbide. The existence of stable double carbides of silicon and zirconium or of solutions of silicon carbide in solid zirconium carbide is suggested as an explanation of the incomplete removal of silicon when carbon in excess of that required to form only silicon carbide is used. Zirconia sufficiently pure for refractory purposes might be obtained from zirkite ore by removing the silicon in an electric furnace and following this by treatment with chlorine or phosgene to remove the iron. In conclusion Dr. Thompson discussed the refractory properties of zirconium carbide and the factors which limit its use.

In commenting on Dr. Thompson's findings, Frank J. Tone of the Carborundum Co. suggested using an excess of iron to remove all of the silicon in the zirkite. The small amount of ferrosilicon formed during the reaction might be removed magnetically. Gillett doubted very much whether such magnetic separation were at all possible; according to his experience it was impracticable. Fink pointed out that part of the iron would be tied up as ferrozirconium. As compared with magnesium oxide or thorium oxide, zirconium oxide is readily reduced at high temperatures. L. E. Saunders of the Norton Co. suggested that Dr. Thompson check his analytical results and try out his ideas on a comparatively large scale, since his present small-scale results are somewhat misleading.

Physical Characteristics of Specialized Refractories.—M. L. Hartmann and W. A. Koehler presented the results of their work at the Carborundum Research Laboratories on the cross breaking strength of special-

TABLE I. COMPOSITION OF INDUSTRIAL LIGHT ALUMINUM-COPPER ALLOYS

Approximate Composition Elements, per Cent		Used for
Al*	Cu	
98	2	Rolling, forging and sand casting.
97	3	Rolling, forging and sand casting.
96	4	Sand casting.
95	5	Sand casting.
94	6	Sand casting.
93	7	Sand casting.
92	8	Sand casting, die casting and permanent mold casting.
90	10	Sand casting, die casting and permanent mold casting.
88	12	Sand casting, die casting and permanent mold casting.
86	14	Sand casting.

* This refers to commercial aluminum containing the usual impurities in subordinate amounts.

ized refractories. The average data are given in Table II.

TABLE II. SUMMARY OF AVERAGE CROSS BREAKING STRENGTHS

	Modulus of Rupture		Ratio	R at 1,350° C.
	Lb. per Sq. In.	20 deg. C. 1,350 deg. C.		
Recrystallized carborundum (Refrax).....	2,312	2,437	1.05	
Bonded carborundum (Carbofrax A).....	2,103	2,274	1.08	
Bonded carborundum (Carbofrax B).....	2,651	2,129	0.805	
Bonded carborundum (Carbofrax C).....	2,215	1,918	0.866	
Silica No. 1.....	608	145	0.228	
Silica No. 2.....	491	178	0.363	
Magnesia.....	1,388	136	0.098	
Fireclay.....	665	113	0.170	
Bauxite.....	1,315	99	0.075	
Chrome.....	1,392	22	0.014	

Discussing the paper, Mr. Saunders warned against basing conclusions on but a few observations. For example, there are clays that have a decidedly higher modulus of rupture than that reported by Messrs. Hartmann and Koehler. Replying to Dr. Richards, Mr. Tone said that one of the large zinc smelters is using carborundum retorts and that these have been found entirely satisfactory.

AN ELECTRIC STEAM GENERATOR FOR LOW VOLTAGE

The first paper of the Saturday, Oct. 1, session was entitled "An Electric Steam Generator for Low Voltage," by F. A. Lidbury and F. A. Samps. The authors described a 250-kw. capacity electric steam-generating unit of the water-resistance type designed primarily for operation at 100 volts, but which could be used without much modification up to 500 volts.

In commenting on his own paper Dr. Lidbury called attention to the lamentable lack of reliable data on the conductivity of electrolytes at temperatures of 100 deg. and above. Frederick T. Kaelin of the Shawinigan Water & Power Co. described the electric steam generator in his plant.

Symposium on Electrodeposition

EFFECT OF PRESSURE ON OVERVOLTAGE

Prof. H. M. Goodwin and Dr. L. A. Wilson of the Massachusetts Institute of Technology presented a paper on "The Effect of Pressure on Overvoltage." Experiments were described in which the overvoltage of hydrogen against copper, nickel and mercury electrodes was determined under pressure varying from one atmosphere to a few centimeters of mercury. The values were determined by the bubble method, at room temperature, under conditions of very low current density, after a state of constant polarization had been established. The results in all three cases showed a rapid decrease at low pressures, confirming the hypothesis recently advanced by MacInnes and Adler to explain overvoltage phenomena.

RESEARCHES ON THE ELECTRODEPOSITION OF IRON

W. E. Hughes of London in his paper on "Researches on the Electrodeposition of Iron" presented the results of the work conducted by many investigators in this field, together with remarks and comments based upon his own experience. The different baths are classified as sulphate solutions, chloride solutions, and sulphate-chloride solutions. He then discussed various researches upon other solutions.

A very lively discussion followed. W. E. Ruder of Schenectady told of his studies of the magnetic properties of electrolytic iron. Dr. Fink referred to the use of electrolytic iron in place of Swedish iron and the

increasing difficulty of obtaining a clean scrap on account of the large quantities of alloy iron (copper, nickel, etc.) in use today. Dr. Blum of the Bureau of Standards discussed the cost item and reported that at present nickel plating is cheaper and more serviceable than iron or steel plating. Bradley Stoughton called attention to the large commercial electrolytic iron plants in France making boiler tubes. The product analyzes 99.97 per cent Fe and is as malleable as pure copper, due partly to the very low carbon content (0.008 per cent C.). He also commented on the large-scale tests of leaching sulphide iron ores with ferric chloride and then depositing out the iron electrolytically. The ferrous chloride is oxidized back to ferric chloride, and this is used in leaching fresh batches of ore. The product analyzes 99.99 per cent Fe. Henry Howard and A. W. Burwell questioned the practicability of the process. F. A. Lidbury surmised that there would be serious anode troubles with a highly corrosive liquor such as ferrous-ferric chloride. G. W. Elmen believed that the chief interest in electrolytic iron was in connection with the use of iron for magnetic purposes, even though Mr. Ruder seemed to think otherwise.

ELECTROLYTIC SOLUTION AND DEPOSITION OF COPPER

Prof. Thomas Roland Briggs of Cornell University presented in his paper on "Electrolytic Solution and Deposition of Copper" the results of his thorough and painstaking research on this subject. He has arrived at conclusions contrary to the general views held by Luther, Foerster, Addicks, Aldrich, Witherell and others and found that the electrolytic behavior of copper in solutions containing copper ions may be accounted for by means of two electrochemical processes: (1) The change from copper to cuprous ion or the reverse; and (2) the change from cuprous to cupric ion or the reverse. When copper dissolves electrolytically at the anode, cuprous ions are formed first. Similarly, at the cathode, copper can be deposited only by the discharge of cuprous ions. The cuprous ions formed at the anode may be removed either by electrolytic oxidation or by chemical means, depending upon conditions. If the removal of cuprous ions is entirely electrolytic, copper dissolves as bivalent metal. If removal is entirely chemical, copper dissolves as univalent metal. If at the cathode cuprous ions are supplied entirely by electrolytic reduction, copper is deposited as bivalent metal. If cuprous ions are supplied entirely by chemical means, copper is deposited as univalent metal. This theory has been successfully applied to the electrolytic behavior of copper in cyanide, chloride and sulphate electrolytes. The theory is a general one and can be adapted to metals other than copper.

Briggs' paper was discussed by Messrs. Fink and Blum, who emphasized the importance of having a good working hypothesis, such as that of Briggs, in conducting researches in electrolytic refining or electroplating.

ELECTROMETALLURGY OF ZINC

W. R. Ingalls, in his paper on the "Electrometallurgy of Zinc," referred to the plants at Great Falls, Trail and Risdon. Under favorable conditions zinc can be produced electrolytically at these plants on terms as low as to permit it to meet any competition. The limitations of the process are that it must be conducted on a large scale and the cost per unit of capacity is greater than that of the ordinary distillation plant. The electrothermic process has been successfully practiced in Scandinavia, especially at Trollhattan in Sweden and Sarps-

borg in Norway. The electrolytic process produces a high-grade zinc at less cost per ton of ore than in the electrothermic method.

Edwin W. Hale of New York, in discussing Mr. Ingalls' paper, stated that according to his electric zinc smelting experience a safe estimate for power consumption is 1,600 kw.-hr. on a 35 per cent zinc ore. In addition to the zinc, he recovered the lead as base bullion and copper as matte. The big advantage of electrothermic smelting is the automatic saving of the by-products. Prof. Richards stated that the furnaces in operation at Trollhattan were not strictly resistance furnaces, but modified arc furnaces. Another interesting process he had witnessed abroad was the recent invention of Cornelius for conglomerating blue powder by rubbing. C. S. Witherell of New York pointed out that the success of any zinc process was dependent upon the quality of the product. A lead-free zinc is in great demand, in particular for alloy work, and there is very little of this product on the market today. The blue powder Dr. Richards referred to contains 20 per cent lead, and accordingly after conglomeration it is necessary to redistill.

STUDIES ON THE ZINC CYANIDE PLATING SOLUTION

In a recent issue of *CHEMICAL & METALLURGICAL ENGINEERING* (vol. 25, page 607) it was estimated that the potential aggregate production of electrolytic zinc for the world amounts to about 250,000,000 lb. per year. The electrolyte is zinc sulphate. Reviving the interest in the cyanide electrolyte, Dr. Chris. J. Wernlund of the Roessler & Hasslacher Research Laboratories, Perth Amboy, reported at length upon "Deposition of Zinc From the Zinc Cyanide Solution." It would seem that although the sulphate electrolyte has much in its favor for the winning of zinc from its ores, in plating practice the cyanide bath is to be preferred. Mr. Wernlund has evolved a zinc cyanide plating solution which will operate successfully under the most trying commercial conditions—i.e., at very high current densities in mechanical plating units where the cleaning of the work is often poor. Following is the composition of the bath recommended, the weights being expressed in ounces per gallon: zinc cyanide 8, sodium cyanide 7, NaOH 1 to 2, Na_2CO_3 4, NaF 1, corn sirup 1, gum arabic $\frac{1}{2}$; temperature of solution 40 to 50 deg. C.; voltage 3 to 5. Very smooth, grayish-white deposits were obtained. The electrolyte does not deteriorate on standing idle.

Dr. Blum took exception to Mr. Wernlund's sweeping conclusions, since the tests at the Bureau of Standards (Bureau of Standards Paper 195) indicated that high concentration NaOH zinc cyanide baths were preferable. Charles H. Proctor referred to the ever-increasing rigidity of the automobile specifications on plated parts. Mr. Wernlund replied that he had tried Horsehead anodes and obtained a porous anode coating of copper and lead. Prof. Richards suggested using as anodes the new zinc cathodes as produced at Great Falls and at Park City without first melting into special shapes, thus avoiding introduction of impurities during melting. Both Richards and Blum lamented the loose way in which the term "throwing power" is used by platers. There are many factors to be considered, such as ion (and not merely "metal") concentration, specific conductivity, and spacing of electrodes, as Witherell added, before fair comparisons are at all possible. George B. Hogaboom, in his usual enthusiastic style, discussed the

increasing importance of closely controlling the compositions of the electrolyte by analytical and physico-chemical means.

ELECTRODEPOSITION OF LEAD-TIN ALLOYS

W. Blum and H. E. Haring of the Bureau of Standards presented a paper on "The Electrodeposition of Lead-Tin Alloys." In the effort to find a satisfactory metallic coating for the inside of air-flasks of naval torpedoes, James S. Groff, chief chemist of the Naval Torpedo Station at Newport, R. I., discovered that it is possible to deposit electrolytically from either fluoborate or fluosilicate solutions an alloy of about 50 per cent lead and 50 per cent tin which has the desired properties. This process, which has been patented by Mr. Groff is now used successfully for the above purpose by the Navy Department. At the request of that department, the Bureau of Standards conducted an investigation to determine the most favorable conditions of operation, and the authors found that it is possible to deposit from fluoroborate solutions alloys of lead and tin, which are finer grained than either of the metals deposited under similar conditions. Lead and tin can each displace the other from such solutions, until an equilibrium is reached, at which the two metals have the same potential. During continued electrolysis with lead-tin anodes, of solutions containing lead and tin, the ratio of the metals in the deposit always tends to approach that in the equilibrium solution.

Charles H. Proctor mentioned that automobile manufacturers would certainly welcome any improvement in applying solder to small steel parts that would lose their temper if heated by the ordinary soldering operations.

William Blum's paper on "The Structure and Properties of Alternately Electrodeposited Metals" will be published in a subsequent issue of *CHEMICAL & METALLURGICAL ENGINEERING*.

Report on the Activities of the Research Council

At the conclusion of the symposium, Paul Moore reported briefly on the activities of the Research Council. The Council was endeavoring to raise enough capital to permit investigators such as Dr. Blum to go on with their investigations unhampered. It is proposed to solicit a subscription of \$100 from each of the large plating concerns. As regards the subject of corrosion a steering committee has been selected, of which William M. Corse is chairman and Dr. Colin G. Fink secretary. The Alloys Information Service and the Committee on Tables of Constants are making good progress.

Meeting of the Board of Directors

The directors of the society met at dinner Thursday evening and again at luncheon Saturday noon.

The invitation of the Baltimore chemists and engineers was definitely accepted. Accordingly, the spring meeting of the society will be held at Baltimore. William H. Boynton of 509 Rose Hill Terrace, Baltimore, is chairman of the committee on arrangements. At this coming meeting there will be a symposium on Electromotive Chemistry in charge of Dr. William C. Moore of the U. S. Industrial Alcohol Co.

The board voted to increase the price of the bound volumes to \$4 to meet the increased cost of publication. It was furthermore decided to publish a ten-year index covering volumes 21 to 40 inclusive.

The Division on Electrodeposition was formally in-

augurated. This division covers the fields of electrolytic refining, electroplating, electrogalvanizing, etc., with Dr. William Blum of Washington as chairman.

The resignation of Dr. P. G. Salom, for many years treasurer of the society, was accepted and Messrs. Hering, Salom and Richards were appointed a committee to report on the finances of the society. A nominating committee comprising Messrs. Fink (chairman), Hering, Mott, Lidbury and Gibson was instructed to report back to the board before Dec. 1. The committee is not an "electing" committee, as is the case in some societies; it will suggest several names for each office of the society to be filled during the term 1921-1922.

Social Features

The outstanding social event that will be remembered for many days to come was the "swimming race" up Mount MacIntyre, in which the ladies in particular distinguished themselves.

An exceptional treat was offered the members on Thursday evening when Prof. Harlow Shapley of the Harvard University Observatory gave a very fascinating illustrated lecture on "Chemistry and the Stars." Remarkable views of the heavens were shown taken through the Mount Wilson telescope, the largest in the world. It was amusing to hear mere electrochemists discussing nebulosity, nebulae and light-years.

The subject of Friday evening's lecture was "Practice of Forestry on National Parks," a very timely and fitting topic. Colonel T. S. Woolsey, Jr., told of the practice in both Europe and America. The timber supply of this country, he said, will last but twenty years more at the present rate of consumption. It takes from 100 to 150 years to grow saw timber; pulpwood requires 40 to 50 years. In discussing the pulpwood growth, Dr. William H. Gesell of Bloomfield referred to the use of catalysts in hastening the growth of trees. Experiments are being conducted by the Brown Co.

Dr. Melvil Dewey, president of the Lake Placid Club, extended a hearty welcome to the society and outlined briefly the history and purposes of the Lake Placid Club.

A cordial reception and tea was tendered the members and their guests at Dr. Dewey's home, situated in the most beautiful spot in the Adirondacks. Here Dr. Dewey demonstrated the secrets of successful filing and his well-known decimal system.

The one pastime which found favor in the eyes of the greatest number of members was golf. Some enthusiasts played nine holes even before breakfast. On Saturday evening Dr. J. V. N. Dorr, chairman of the golf committee, distributed the prizes. L. J. Buck received a fine club for the best score in the kickers' handicap. John B. Glaze got a second prize, a Monel metal golf head. Dr. Parmelee, editor of CHEM. & MET., and Mr. Terry of the Dorr Co. were rewarded for the most sensational plays in the foursome. Mr. Corse drew four golf balls, and Mr. Baily a tee for modesty in the kickers' handicap, having asked for a handicap of 68. To Mrs. Baily was awarded the ladies' prize, a ball which will automatically retrieve. At 10 o'clock Saturday evening the club arranged for a magnificent fire and water spectacle on Mirror Lake.

Sunday morning, amid animated farewells, the many who had come in automobiles departed, and as they passed and repassed each other on the downward trail, goodbyes and parting sallies flew from car to car. Thus ended what will be remembered by all as one of the most delightful episodes in their lives.

Water-Power Resources of Canada

During the past two years there has been under way in the Dominion Water Power Branch of the Canadian Department of the Interior a careful re-analysis and computation of Canada's water-power resources. All existing stream flow and power data available from dominion and provincial sources have been systematically collated, analyzed and co-ordinated with a view to preparing, on a uniform basis from coast to coast, revised estimates of the power available. While the analysis is not yet finally completed, sufficient progress has been made to warrant the publication of the figures given herein.

The figures listed in the accompanying table are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration is definitely known or at least well established. The power estimates have been calculated on the basis of 24-hour power of 80 per cent efficiency for "ordinary minimum flow" and "estimated flow for maximum development."

An analysis of the water-power plants scattered from coast to coast concerning which complete information is available as to turbine installation and satisfactory information as to stream flow gives an average machine installation 30 per cent greater than the six-month flow maximum power. Applying this, the figures quoted therefore indicate that the at present recorded water-

AVAILABLE AND DEVELOPED WATER POWER IN CANADA

Province	—Available 24-Hr. Power at 80%— Efficiency		Turbine Installation, Hp.
	At Ordinary Min. Flow, Hp.	At Est. Flow for Max. Dev. (Depend- able for 6 Mo.), Hp.	
British Columbia.....	1,931,142	5,103,460	304,535
Alberta.....	475,281	1,137,505	32,492
Saskatchewan.....	513,481	1,087,756
Manitoba.....	3,270,491	5,769,444	83,447
Ontario.....	4,950,300	6,808,190	1,052,048
Quebec.....	6,915,244	11,640,052	925,972
New Brunswick.....	50,406	120,867	21,180
Nova Scotia.....	20,751	128,264	35,774
Prince Edward Island.....	3,000	5,270	1,933
Yukon and Northwest Ter- ritories.....	125,220	275,250	13,199
	18,255,316	32,075,998	2,470,580

power resources of the dominion will permit of a turbine installation of 41,700,000 hp. In other words, the present turbine installation represents only 5.9 per cent of the present recorded water-power resources.

The total hydro-power development installed during the past year or now under construction represents approximately 560,000 hp. of installed capacity. This figure includes only the initial installations of plants under construction, not their ultimate designed capacity.

Should the rate of water wheel installation during the past fifteen years be maintained, there will be installed in 1925, 3,360,000 hp.; in 1930, 4,110,000; in 1935, 4,860,000, and in 1940, 5,600,000. There is every reason to expect that the rate of growth in utilization will be accelerated rather than retarded.

The water power now developed in Canada represents an investment of \$475,000,000. In 1940, should the rate of growth in installation during the past fifteen years be continued, this investment will have grown to over \$1,000,000,000. The present development represents an annual equivalent of 18,500,000 tons of coal, which, valued at \$8 per ton, represents \$148,000,000. In the year 1940 these annual figures will, with the foregoing assumption, have become 42,000,000 tons and \$336,000,000.

Industrial Training and Selection of Personnel

An Analysis of Some of the Common Shortcomings of Industry and School—Outline of the Basic Principles Underlying Modern Methods of Selecting and Training Employees, and Some Helpful Suggestions for Solving Personnel Problems

By C. R. DOOLEY

Manager, Personnel and Training, Standard Oil Co. (New Jersey)

"SQUARE pegs in round holes" is an old figure, though none the less true; yet it contains an implied suggestion that round pegs in round holes, all working smoothly, would be an ideal condition. Not so—that is, if the fitting of the pegs and holes is to be done by some automatic system, even a scientific one. In the end people will not be content with being put in their right places; the process must be self-determinative. Otherwise life is not worth living, and as long as dictated authority rules there will be unrest and terrible waste. No one will or can do his best unless he is following his own ambitions, developing his own life. How then can individual freedom be co-ordinated into a single effective effort for the good of the whole community? This is the whole problem of industrial organization, toward which I hope to be able to contribute a few helpful suggestions—not a solution—in connection with the selection and training of men and women within industry.

WISE POLICIES OF RECOGNITION AND PROMOTION

First, the progress of any individual within an industry must be according to merit, and merit alone. Recognition and promotion must have nothing to do with family relationships, society or club memberships, personal whims of high officers or even the ownership of the business. There must be no more chance of a position of foremanship being given to a man because of his connection with the general manager than the captaincy of an athletic team should go to the owner of the athletic field.

Recently an officer of a large corporation needed a secretary and proposed the daughter of an old friend, to whom he was indebted for many favors. However, the personnel manager was able to persuade him to advance one of the young women within the company, thus preserving the morale among a hundred young women, each of whom hopes for advancement and works diligently to deserve it.

The chance for recognition may be one in a thousand, but upon that spark of hope hangs the highest grade of efficiency. Nothing is so deadening as the hopelessness of recognition in the face of inherited or political advantages. Merit is of course not always easy to determine, even when an honest effort is made. In the last analysis one man's merit is largely another man's judgment. But men do not resent the frank honest judgment of their superiors so long as they know they've had a fair chance. Every day one hears criticism of favoritism, but over a long experience I have never heard an honest judgment criticized even if very disappointing.

Perhaps the second most deadening influence to initiative and creative effort is a blanket seniority rule. A good rule, other things being equal—but other things

never are equal. In matters of discharge as well as promotion the personal record and personal qualities alone should count. Such a policy is a far greater stimulus to young men than increased wages.

Assuming now that our policy is "Let the best man win," how is he to be selected with reference to the work he is to do, and then how is he to be introduced to his work? These are big questions, and again I can only make a suggestion or two.

ADAPTABILITY OF THE INDIVIDUAL

It is a fallacy that all men are created equal. Each of us can do certain things better than other things, therefore we should not expect all young men to climb the same ladder to success. A promising young salesman may be poor at routine office work, yet he may need a certain amount of experience in the office before he is given a larger sales position. Indeed a good sales manager may not be an especially successful salesman. A chemist producing many improvements in processes each year may not be the man to place as manager of the research department.

It is difficult to transfer a man successfully from one general branch (such as manufacturing, accounting and selling) of a business to another branch, not only because his previous experience has been so decidedly different, but because of certain fundamental native qualities of mind and personality. Most men, if started right, will advance most successfully by remaining within a given branch of a business. Then again men differ as to their adaptability to outside or inside work, and also as to their ability to start new enterprises or to close and finish them. Some men are by nature individualists; they work best absolutely alone; system and assistance hamper them. These must not be discharged for lack of discipline, but used where their kind is needed. Others need the close association of other men's minds in order to contribute their best. These are organization men, better for planning than executing. So all men should be considered as to their type—manufacturing, accounting, commercial, financial, promoting, scientific, office, field, organization, etc.

Men of middle life are obviously selected because of their attainments, personal or technical. They will largely take care of themselves, but young men should be selected for their potentialities, their native qualities and possibilities of development.

BASIS FOR SELECTING YOUNGER MEN

Confining our attention from now on to the problem of the young man, the basis of his selection should be a series of rather personal questions in an effort to find out a great many things the man has done since he was a small boy and what his motives have been.

As a child did he wear out the toys his parents bought him, or did he invent and make his own playthings? If he sold papers, what methods did he devise to carry on the business and did he operate his own business or carry papers for another man? If he worked his way through school, just how did he do it? How much money has he earned during vacations? At what kind of work? What did he do with his money? If he has had several jobs since leaving high school, what were they and why did he change? Is his purpose always placed ahead of the pleasure of the moment? To have done his duty is expected, but how clearly has he had some kind of plan even in boyhood?

If he carried responsibilities as a boy, he will be apt to carry them well as a man. If he had a commercial interest as a boy, he probably will continue in that as a man; and if he was clever with simple mechanical devices as a boy, he will continue to exercise a constructive imagination with mechanical things as a man. A few fundamental types of men seem to hold true clear back to their earliest recollections. Some of these types are: inventive or constructive engineering, analytical or research engineering, commercial individualist, and commercial organizer.

The interview, of course, should include all such personal data as age, parentage, place of birth, business of parents, habits, athletic interests, height, weight, color, etc. Some rules may hold true generally but there are many exceptions, and only when you know the whole story of a man can you make a final estimate.

IMPORTANT QUALIFICATIONS TO BE CONSIDERED

There are many desirable personal characteristics, and each interviewer will emphasize different ones. There can be no one standard list of qualifications for all interviewers to use, but anyone attempting to select young men should adopt some list of qualifications which he believes more or less describe a man. I have found that different men pick equally good men, although each uses different methods and each calls the important qualification by different names. In general, the following characteristics may be considered in selecting young men for training in any business:

1. *Moral Fiber.*—Integrity, honesty, reliability, a spirit of helpfulness, modesty, refinement, ability to work in an organization, co-operativeness, tactfulness, etc. In short, those things which make a man liked and respected and trusted among his fellow-men. He is acceptable.

2. *Personal Power.*—Originality, initiative, resourcefulness, vision, ability to discriminate between essentials and non-essentials; courage, readiness to accept responsibility, understanding of men, etc. In short, those things which designate a man as an original contributor in some way to the world's progress. He gets things done.

3. *Technique.*—Technical knowledge, special experience, kinks of a trade or profession, data, formulas, etc. In short, those facts which he acquires either from books or from experience. He knows how.

To summarize these points in the reverse order, the third represents the required tools with which he works; the second is his ability to use these tools; and the first is his character, or his passport which permits him to work with the rest of us.

The majority of young men, especially those graduating from college, have the first of these qualifications

and a considerable portion of the third; but, on the other hand, two-thirds of them are lacking in the second.

THE BASIC PRINCIPLE IN EFFECTIVE TRAINING

With this general philosophy as a background, it is necessary to develop a method of training which will not only teach men a certain number of technical formulas but will develop within them the originality and initiative necessary to successful original application of these formulas. After a number of years of experimenting with young men varying in age from fourteen to thirty, some having only a part of the public school education and some having been graduated from college, there is one universal deduction which may be stated here as the basic principle in all effective education or training, whether in the academic class room or the practical shop.

Technical information should be presented to students in the form of jobs or problems or projects or questions, and these should be presented in advance of formal explanation of methods of solution.

Many problems simply take the form of questions, but the answer to these questions should never be given in systematic form. Of course, the problems and questions must be arranged in some order of difficulty, so that each problem means a step forward. Obviously a young machinist should not be started on a gear-cutting machine before he has had some of the simple bench and lathe work, or a young salesman should not be sent to the most difficult customer first. On the other hand, each job that is put up to either of these two men should be a real job and not have all of the punch taken out of it by being thoroughly explained beforehand. Memorized lectures do not stick with us; or if they do, they never become a part of our real experience. They are always superficial in their relation to our best actions.

MUCH TIME AND PATIENCE REQUIRED

It is a difficult and serious task to teach by this method. It takes time and much patience. For the head of a department to explain carefully to his young assistant all of the difficulties which the young assistant is likely to encounter during the day, or to explain nothing, but merely storm at him at the end of the day after he has made a mistake, are both easy things to do.

The old "sink or swim" methods produce poor swimmers and many drownings. On the other hand, too many swimming lessons given on land take all of the spirit and initiative out of men by teaching them in detail how swimming is done but never how to swim.

The right thing to do and the difficult thing to do is to give just enough fundamental information at the beginning to set the boundaries or policies within which the young man is expected to act, and then at a later time to discuss with him the details of his experience in a way which will help him to analyze them and come to his own correct conclusions.

Many department heads object to instructing new men continuously and losing them even to other departments within the same organization. They prefer low-grade men who "stay put" to men of larger ability and ambition. There may be a question as to the number of high-grade men to train in any one organization, but there can be no doubt as to the most effective method of training, and further this method will show that all men are better than had been supposed—and that some are a great deal better.

When this process becomes too burdensome to the executive staff, it is time to set up a special training school. The method is simple: First you provide a series of actual work assignments where the experience is real, and then you provide a series of class meetings for discussion of each man's experience, following an outline of problems and questions which are given him in advance.

The instructor now becomes a mere referee who decides disputes and sees to it that the men do not get wrong information. He insists that the answers to all questions be deduced from the personal experience of each man, and by continual quizzing he keeps the men going in the right direction. A lecturer is the poorest kind of a teacher for developing real personal power. Occasionally a lecture or talk given by some officer or expert has a good effect by way of general inspiration, but this part of an educational program should be a small percentage.

SELECTING THE PROPER SORT OF TEACHER

The best kind of teachers are men selected right from the offices or shops, each man an authority in his subject. All men who are competent workers do not make good teachers, but all teachers should be competent in their work or profession and should be engaged in the practice of it, giving only a portion of their time to teaching.

In addition to being competent at his work, a teacher should have an inspiring personality and an enthusiastic way about him to get under the skin of young men. Generally a man who is competent at work and who expresses a keen desire to teach purely for the love of helping young men makes a good teacher. Such a man should be young enough to be flexible so that the head of the training department can mold him in the understanding and practice of this general philosophy of teaching. He must be interesting and his class meetings must be interesting.

METHODS OF INSTRUCTION WHICH DEVELOP INITIATIVE

This is the whole trouble with teaching. We teach young people how things have been done instead of why they are done or, better yet, we should teach them to think out for themselves the "why." Instead we standardize forms to be memorized and call it education. We not only standardize arithmetic, but we standardize the method in which it shall be presented, adopting a full set of technical terms. For example, when the young student finishes simple interest in the public schools he turns over a page and begins compound interest, which he has heard from his fellow students a grade ahead of him is exceedingly difficult, and accordingly he enters upon its study with diffidence.

Now the fact is that, mathematically speaking, there is no such thing as compound interest. It is only simple interest repeated with a new principal. The new principal is the old principal plus the interest for a given period which a man has been unable to pay when due. The reason that it is due on a given date and that after that it becomes a part of the new principal is purely a matter of custom among people, and has nothing to do with mathematical principles. If this were explained in connection with problems in simple interest and then the name "compound interest" given merely incidentally as a convenient term to use in talking about such a

problem, the whole subject of compound interest would disappear.

The same thing is true of electricity, which I have studied thoroughly, practiced intensively and taught personally to almost every kind of student. Some of the electrical theory is complex and difficult, but a great deal of it is exceedingly simple when stripped of its mysterious terms.

The average shop mechanic pays profound respect to a piece of blue paper covered with white lines, and yet blueprinting has nothing to do with mechanical drawing, but is only a means of cheap duplication. Even the principles of drawing are mystified by a technique called "projection." Mechanical drawing is a language used to express ideas in terms of flat surface pictures and is not a matter of beautiful lettering and shading of lines. The fundamentals are as simple as arithmetic and could easily be taught in the grammar grades without either blue paper or expensive drawing tools.

We continually shroud ourselves in technical terms which we endeavor to force young people to memorize, and in so doing we tend to crush what originality and initiative they have in the beginning. In teaching technical subjects only fundamental principles should be considered and great emphasis should be placed upon their correct application to original problems, free from tradition and customs. Of course, as society is organized, a certain amount of form is called good. We must have correct spelling and some style to our dress, and yet the moment form begins to add to our dignity rather than to our efficiency we begin to stifle initiative and originality.

BRINGING THE INDUSTRY AND THE SCHOOL TOGETHER

All of this is a very roundabout way of saying that in our training processes we must first of all develop what we may call industrial intelligence and not merely require routine memorized formulas and standardized methods. We must encourage men to vary from things as they are today. We must stimulate the research point of view, the habit of eternal inquiry after better ways, for only through this can we ever hope to develop the leaders of the future.

This can be done normally and without forcing by beginning with the work, or the job, and approaching the student with a discussion of many questions about the job. If the student rises to the occasion and comes back with original contributions, you know he is growing and it is your business, employer as well as teacher, to keep him growing to the limit of his capacity. Some men will never respond greatly, and therefore will continue in the routine performance of their present work. All of us cease to respond sooner or later and thereby we find our level.

The trouble with our schools has been that they artificially pull people above their levels by forcing memorized formulas.

The trouble with industry has been that it artificially holds men below their levels through lack of opportunity to study out the science underlying their work, and through arbitrary authority.

When these two things are brought together—when the spirit of the teacher pervades industry and the spirit of production furnishes the background for education, then all people will find their levels automatically and remain there without chafing under arbitrary authority.

To make this function in practically any organization, two kinds of training must be provided: (1) That which young men just starting into business are obliged to take because of a company's determination to select and train for efficiency. (2) That which any man in the business who is ambitious to improve himself may take according to his own option.

THE THREEFOLD PURPOSE OF TRAINING

In both cases, however, the method of teaching should be the same and should have a threefold purpose: (1) To inspire the highest quality of American manhood, although if a man has not a fine moral fiber, integrity, honesty, reliability, etc., he is not worth the trouble of training. (2) To discover and develop personal power in the use of knowledge under new and trying circumstances. (3) To establish a certain amount of accurate fundamental knowledge.

No matter how large and complex the organization, each individual must be treated upon his own record, as an individual in open frank honest competition with his fellows. Training courses, for the most part optional, must be available to guide young men and women in working out their ambitions and to assist department heads and officers of concerns in the discovery of latent talent. The routine work of the day serves well to develop character, to test out loyalty, obedience, thrift, etc., but it is often not stimulating and intellectual depths are not challenged. On the contrary, practical problems presented by an inspiring instructor in the class room appeal to the intellectual powers and bring out latent abilities not hitherto suspected. Moreover a training program fills young employees with the belief that they have a chance, that the "Old Man" is now going to play square with them. With this attitude of mutual confidence and mutual helpfulness the pegs will find their proper holes naturally.

Personnel adjustments to be successful must be done impersonally by the authority that comes from skill and special knowledge and not the authority of official position.

There are managing talents and special abilities among the rank and file of people, if those in authority will only take the trouble to find them—and be willing to give them a chance according to their true merit.

New York City.

Canadian Linseed Oil Industry in 1918

Though no statistics from which comparisons can be drawn have been compiled previously to those just issued by the Canadian Bureau of Statistics for 1918, the production of flax seed and the manufacture of linseed oil in Canada are industries that are beginning to assume considerable proportions. During 1918 more than 6,000,000 bu. of flax seed was produced, about half of which, having a value close to \$8,000,000, was exported. Of the remainder 1,360,000 bu. was used for the manufacture of oil, and from this was produced 1,144,000 gal. of crude and 733,000 gal. of refined linseed oil, having a combined value of \$4,063,000, and 24,366 tons of oil cake, having a value of \$1,374,500.

Seven plants, representing an investment of \$2,500,000 for land, buildings and machinery, were in operation during the year and nearly \$200,000 was distributed in wages. Sundry byproducts, such as greases, stearine and fertilizers, also were manufactured at the several plants.

Hardness Variations in Heat-Treated Steel

BY CARLE R. HAYWARD

IN STUDYING the properties of different steels the writer has often been struck by the fact that the center of a heat-treated bar is with rare exceptions harder than the material nearer the edge. This difference in hardness has been most noticeable when testing with the Shore scleroscope, for a majority of the specimens have been only $\frac{1}{2}$ in. in diameter and the Brinell tests were taken only at the center.

I have made no extensive series of tests to study adequately the progressive change in hardness from center to circumference, but a few figures giving values obtained with several steels may be of interest and may possibly call forth others from other investigators.

One steel with an analysis C 0.42, Si 0.07, Mn 0.79, S 0.015, P 0.016 after quenching in water from 850 deg. C. and reheating to 400 deg. gave the following hardness tests on a polished cross-section:

Time Reheated	Shore Test at Center	Shore Test Near Edge
15 min.	30	28
30 min.	29	25
1 hr.	27	20
4 hr.	26	19

In another series of tests the steel used had the following analysis: C 0.46, Mn 0.56, S 0.055, P 0.010.

The specimens $\frac{1}{2}$ in. in diameter were quenched from 850 deg. in tap water and reheated to 300 deg. for 5 min., 15 min., $\frac{1}{2}$ hr., 1 hr., 2 hr. and 4 hr. Another piece in the original condition was annealed at 850 deg. for 15 min. and cooled in the furnace. The scleroscope tests on a polished cross-section were as follows:

Time Reheated	Shore Test Center	Average of Six Tests Nearer Edge
Quenched	45	42
5 min.	30	24
15 min.	32	27
30 min.	25	20
1 hr.	25	17
2 hr.	29	25
4 hr.	32	28
Annealed	17	15

Although these results seem somewhat inconsistent, one striking point is brought out. In 5 min. reheating, the hardness dropped to two-thirds the figure found for the quenched specimen and remained approximately constant for 4 hr. In every case the center was harder than the average of the remaining surface.

Another steel of nearly the same composition was quenched in the same way as above, but the reheating was carried out at 400 deg. C. Composition of steel: C 0.44, Mn 0.58, S 0.042, P 0.007.

Time Reheated	Shore Test Center	Average of Six Tests Nearer Edge
Quenched	47	43
5 min.	36	33
15 min.	32	22
30 min.	27	23
1 hr.	23	17
2 hr.	27	19
4 hr.	25	21
Annealed	18	16

With the exception of the 1 hr. treatment the figures are in this case consistent. The drop in hardness during the first 5 min. heating is again striking, though in this case it is only 20 per cent instead of 33, as in the 300 deg. heating.

A third $\frac{3}{4}$ -in. steel bar varying slightly from the last two was quenched in the same way, but reheated to 500 deg. C. Composition of steel: C 0.48, Mn 0.58, S 0.048, P 0.007.

Time Reheated	Shore Test Center	Av. of Six Tests Nearer Edge
Quenched	44	45
5 min.	30	26
15 min.	25	18
30 min.	26	21
1 hr.	20	17
2 hr.	26	22
4 hr.	28	23
Annealed	20	17

The tests on these specimens were somewhat erratic, but again the same tendency is brought out.

All the above figures were obtained incidental to other tests. In order to see what effect heating to 700 deg. would have on the hardness three pieces of the last steel were quenched and heated for 20 min., 1 hr. 10 min., and 2 hr. respectively at 700 deg. C. The results were as follows:

Time	Shore Test at Center	Shore Test Half Way to Edge	Shore Test Near Edge
20 min.	24	20	17
1 hr. 10 min.	23	20	15
2 hr.	23	19	15

These results are nearly the same as on the annealed specimens. It is interesting to note that practically the full effect took place in the first 20 minutes.

Some pieces of $\frac{3}{4}$ -in. round carbon tool steel containing 90-100 point carbon were quenched in water from 850 deg. C. and reheated for 20 min., 1 hr. 10 min. and 2 hr. at 350 and 600 deg. C. The hardness results were as follows:

Time of Reheating	Shore Test at Center		Shore Test Half Way to Edge		Shore Test Near Edge	
	350°	600°	350°	600°	350°	600°
20 min.	29	26	27	25	25	23
1 hr. 10 min.	30	25	28	24	28	22
2 hr.	30	24	28	22	27	20

Again there is a difference between the center and the edge, but not so great as in medium-carbon steel.

All the figures thus far presented are with the Shore instrument. In order to get some results with the Brinell machine some pieces of 2-in. steel shafting 2 in. long were quenched in water from 850 deg. C. and reheated to 350 and 600 deg. for 20 min., 1 hr. 10 min. and 2 hr. They were then sawed at the middle, polished in cross-section and tested.

Time	Shore Test at Center		Shore Test Half Way to Edge		Shore Test Near Edge	
	250°	600°	350°	600°	350°	600°
20 min.	24	22	23	21	22	20
1 hr. 10 min.	24	22	23	21	22	20
2 hr.	23	23	22	21	22	21

The Brinell hardness of the last specimen was center 149, half way to edge 137, near edge 126.

This steel is so low in carbon that the Shore test shows little variation either for temperature or time. The Brinell numbers are more divergent than the Shore numbers.

DISCUSSION OF RESULTS

The figures, taken at random as they are from the writer's files and obtained from a variety of steels, are in no sense an adequate research into hardness phenomena from which definite conclusions may be drawn.

There are several indications regarding the effect of temperature and time on hardness which more data might confirm or disprove, but one fact is outstanding: All cases cited and many more which are not mentioned in this paper show a greater hardness at the center than near the edge, regardless of heat-treatment. This is not due to decarburization, for the tests were made far enough from the edge to avoid this.

The probable explanation is either the McCance inter-strain theory or possibly the theory recently published by Jeffries and Archer.

All steel on cooling is subjected to internal strains varying in intensity with the rate of cooling. Even a steel very slowly cooled is subject to a small amount of this strain. It is evident that in all cases the effect is greatest at the center of the specimens and according to the new theory a variation in hardness is to be expected. Once hardening by slip or interference in grain growth is produced, varying from center to outside, it is impossible to eradicate it completely. At drawing temperatures near the critical range equalization is approached, but if it is ever attained during heating, which may fairly be doubted, a slight differentiation takes place during cooling. E. E. Thum has suggested to the writer that at least part of the excess hardness at the center, especially that shown after complete annealing of the specimens, may be due to the segregation which always occurs to some extent at the center of an ingot and persists in rolled bars. This fact should not be overlooked, for it is a reasonable explanation of at least part of the phenomena. The entire explanation can be found only by a careful research involving chemical analyses from center to circumference supplementing the hardness data and microscopic analysis. It seems fair to assume that it is practically impossible under ordinary heat-treatment conditions to expect a bar of steel to be homogeneous in hardness throughout its cross-section.

Wood Acids*

"Acid" is a term used by many to designate almost any kind of chemical which has a corrosive action, and, in the same loose sense, the term "wood acid" is used in explanation of any unusual quality in a wood, such as taste, odor or corrosion of metals in contact with the wood. As a matter of fact, only three chemicals correctly called acids have been found existing free in wood; these are tannic acid, acetic acid and formic acid. Tannic acid is very feeble and has very little corrosive action on metals. The two other acids are also feeble in comparison with sulphuric, nitric or hydrochloric acid.

A very small amount of acetic acid and a still smaller amount of formic acid apparently exist in all native woods, probably as the result of a slow action of water on wood at ordinary temperatures. All native species are also alike in that both of these acids can be produced very readily from them by the simple action of steam or hot water, a reaction for which there is no simple preventive treatment. Acids formed in the wood by the agency of steam or hot water are doubtless responsible for the results frequently attributed to acid supposed to have been in the wood originally.

The amount of acid normally present in any native wood is not sufficient to warrant its rejection for any purpose involving contact with metals.

*From U. S. Forest Products Laboratory Technical Notes.

The Amorphous Metal Hypothesis

The Amorphous Metal Cement Hypothesis Is the Only Satisfactory Explanation of the Properties of the Grain Boundaries in Metals—The Role of Amorphous Metal in Plastic Deformation and Particularly in Producing Hardness Has Been Greatly Exaggerated

BY ZAY JEFFRIES AND R. S. ARCHER

ALTHOUGH solid metals are in the main undoubtedly crystalline in structure, there is reason for supposing that they may exist partly in an amorphous condition, and that those portions which are amorphous may exert a very important influence on the properties of the aggregates. This view was first advanced some twenty years ago by George T. Beilby¹ largely as a result of his studies on the nature of polished surfaces. It has since been elaborated and extended, notably by Rosenhain², so that the amorphous metal hypothesis now occupies an important but somewhat uncertain position in modern metallographic theory. It is the purpose of this article to recount the principal elements of this hypothesis and to present a critical discussion and a statement of the hypothesis which is believed to be consistent with the results of recent research.

DEFINITION OF "AMORPHOUS"

Crystalline materials are characterized by the orderly arrangement of their constituent particles—i.e., atoms or molecules—in definite geometrical patterns. Materials whose molecules do not possess any such regularity of arrangement are amorphous. The term "amorphous" is thus in the broadest sense directly opposed to crystalline. A further distinction must be made. Wood is a material which is decidedly not crystalline, and yet because of the processes of its growth it possesses definite directional properties. The arrangement of its atoms or molecules is not entirely haphazard. The same is true of all vegetable and animal tissues. In order to define more specifically what he meant by the term amorphous in connection with metals, Beilby used the qualifying adjective "vitreous," narrowing the field to "substances which in some degree resemble the glass-like form assumed by the silicates when they are solidified from the molten state."

Amorphous solids are essentially undercooled liquids of great viscosity. The constitution of the liquid is preserved and with it the property of fluidity, masked from casual observation by the high viscosity. Glass may be taken as an example. On cooling from the molten state it passes in a continuous manner from a liquid which can readily be poured to the solid we know at ordinary temperatures with a hardness comparable to that of the hardest steel. In spite of this hardness, a rod of glass supported at the ends will sag or "flow" under its own weight in the course of months or years.

It has been pointed out in a previous article³ that the regularity of atomic arrangement in crystals leads to mechanical weakness along certain crystallographic planes. The absence of such planes of weakness in amorphous materials leads to great hardness at low temperatures. The hardness and strength of amor-

phous materials will be discussed later more fully. For the present it is merely necessary to say that the amorphous modification in most metals is regarded as being harder and stronger than the crystalline at ordinary temperatures.

AMORPHOUS FILMS ON RUBBED SURFACES

The studies of Beilby referred to above showed that the operation of polishing causes a surface flow of the material being polished. The action of abrasive materials is essentially one of cutting. The grinding of a metal surface by an abrasive such as emery consists in the cutting of minute grooves, the emery particles acting as cutting tools. When such a surface is polished or burnished, the surface layers of the metal are caused to flow, bridging or filling up the grooves left by the emery. Working with the mineral calcite (calcium carbonate), which is especially suitable for such observations, Beilby found that the flowed surface possessed certain properties which distinguished it from the unpolished crystal face. It was harder, as tested by the loaded needle, and its hardness was the same in all directions, whereas the hardness of the natural crystal face varied according to the direction in which it was measured.

Perhaps the most significant thing is the way in which the polishing operation gradually smoothes over the scratches, finally obliterating them and leaving a surface with an appearance "absolutely homogeneous and vitreous like a coating of varnish or enamel." Furthermore that this smooth surface is merely a coating is demonstrated by the fact that the scratches are again revealed when the surface layer is dissolved in hydrochloric acid. Beilby concluded that the flowed material is rendered amorphous by the action of polishing. This amorphous film was assumed to be in a condition of great mobility at the instant of formation so that under the influence of surface tension it would assume a very smooth surface. It was then supposed to solidify or "set" in the final hard glassy state.

It had already been shown that the permanent deformation of metals takes place by a kind of block movement on certain crystallographic planes known as gliding planes or slip planes. Beilby postulated that the rubbing of the crystal fragments over each other on the slip planes generates films of amorphous metal comparable to the surface films produced by polishing. Like the surface films, they were supposed to pass through a mobile stage and then become hard and rigid. Now the ductile metals are greatly hardened and at the same time made brittle by deformation carried out below the annealing temperature, whether such deformation be effected by cold-drawing, rolling, pressing or other means. According to Beilby's theory, this "hardening" results from the formation at all the internal surfaces

¹See references and footnotes on page 704.

of slip or shear of mobile layers similar to those produced on the outer surface by polishing. These layers retain their mobility for only a very brief period and then solidify in a vitreous amorphous state, thus forming a cementing material at all surfaces of slip or shear throughout the mass." The increased hardness is thus attributed to the presence of a framework or matrix of a modification of the metal possessing greater specific hardness than the crystalline modification.

After this stiffening of the metal, further deformation is forced to take place on new slip planes, thereby producing more amorphous metal and still greater hardness. There is a practical limit to the amount of cold deformation that a metal will endure. Further attempts cause rupture. Thus in wire-drawing if the process is carried too far the wire draws hollow or splinters. Even before this stage is reached maximum hardness and strength are produced. Over-drawing reduces the strength. This is regarded by Beilby as due to the exhaustion of available crystalline material. The crystalline modification of the metal is regarded as the sole source of plasticity and when the available supply is exhausted the metal becomes incapable of further deformation.

RECRYSTALLIZATION

Metals which have been hardened by cold-work are softened by heating to a suitable temperature. The softening is accompanied by the restoration of ductility and by the substitution of a clearly crystalline structure of equi-axed grains for the disordered structure found after cold-working. This operation is called "annealing," and is a regular part of most industrial processes involving the cold deformation of metals. The softening is explained by Beilby's theory as due to the recrystallization of the amorphous metal produced by the cold-work. Disappearance of the amorphous metal of course involves the simultaneous disappearance of the hardness and brittleness supposed to be due to it.

Crystallization of an amorphous solid or undercooled liquid is a common occurrence. Glass and vitreous silica crystallize or "devitrify" when exposed for a long time to temperatures at which they are somewhat soft. The presence of crystalline nuclei greatly facilitates this transformation. Beilby considers the recrystallization of metals to be strictly analogous to that of other amorphous materials in the presence of nuclei. The nuclei are the fragments supplied by the breaking up of the original crystalline grains. The amorphous metal is regarded from the physicochemical viewpoint as identical with the liquid phase. Hence it must be unstable at all temperatures below the melting point of the metal and is prevented from reverting to the stable crystalline form only by its rigidity due to the low temperature. On raising the temperature of a metal the atomic mobility becomes sufficient for the unstable amorphous phase to crystallize about the nuclei already present.

OTHER METHODS OF PRODUCING AMORPHOUS METAL

Beilby did not consider deformation to be the only means for the production of amorphous metal. He recognized that it is not possible to retain metals in the amorphous condition by rapid cooling from the molten state, as is the case with glass, vitreous silica and many other typical amorphous solids. He did, however, advance the suggestion that "the evolution of a dissolved gas when a critical point is reached may so

effectually prevent or modify crystallization that the metal is hardened." And again, "Sometimes a very minute addition of a second substance to a pure metal is sufficient to prevent crystallization in the regular way, or even to prevent it altogether. The product is then more rigid and less plastic than the pure metal." This statement was offered as an explanation of the fact that solid solutions of two metals are usually harder than the pure metals, the case of gold and silver being mentioned as an example. Another suggestion was that amorphization might be brought about by flow occurring in a cooling mass as a result of shrinkage strains. Certain samples of electro-deposited copper are found to be very hard and to possess a structure somewhat resembling that of cold-worked metal. Annealing causes recrystallization and softening. From these observations Beilby concluded that "the deposition of the metal under conditions of strain had caused the molecular aggregation to be of the amorphous type." These suggestions are interesting to note in tracing the development of the theory. Beilby sums up thus:

"The development of the maximum intrinsic hardness of the metals can thus be brought about in many different ways, but in every case it appears to depend on the special development of the cohesive forces which is associated with the amorphous or non-crystalline aggregation of the molecules."

WHAT CEMENTS CRYSTALLINE GRAINS TOGETHER?

In 1912 Beilby's hypothesis received a very important extension, consisting in the proposition that the amorphous phase exists not merely in cold-worked metals but is also a normal constituent of all metals in the form of an intergranular cement.* Beilby's original hypothesis that amorphous metal is formed on slip planes during plastic deformation was put forth to explain hardening. The postulation of an amorphous intergranular cement was advanced to explain an entirely different set of phenomena, which will now be briefly described.

When pure metals that are in what may be called "a normally healthy condition" are broken, the path of fracture is found to pass almost exclusively through the grains, rather than between them. The grain boundaries appear to be stronger than the grains themselves, rather than weaker, as might be expected. When metals are broken at temperatures just under their melting points, however, the conditions are reversed, fracture following the grain boundaries.

Permanent deformation of metals consists of plastic deformation of the crystalline grains, by the process of slip or gliding. If the grains possess any inherent plasticity, as is normally the case in the ductile metals, then fracture through the grains is necessarily preceded by some plastic deformation of the grains and a general deformation of the metal as a whole. Transcrystalline fracture is therefore accompanied by a ductile break. Intergranular fracture at high temperatures, on the contrary, takes place in a brittle manner—i.e., with little if any general deformation of the metal. The cohesion between grains has become so small that they pull apart before sufficient load can be transmitted to deform them.

The assumption that the grains of metals are held together by a cement of a vitreous amorphous nature explains these phenomena in a very satisfactory manner. At the lower temperatures this cement is hard

*See references and footnotes on page 704.

and strong, so that the necessary loads can be transmitted to the grains to deform them and finally cause rupture to pass through them. As the temperature is raised the amorphous cement gradually softens⁴ so that at high temperatures it is very weak. The grains then readily pull apart without any appreciable deformation.

TIME FACTOR IN LOADING AMORPHOUS MATERIAL

Since the atoms (or molecules) of amorphous materials do not occupy fixed positions with respect to one another, such materials can be deformed by the gradual shifting of the relative positions of their particles. The atoms in a crystal of metal are held in substantially fixed positions in the crystal lattice. Deformation therefore takes place by the simultaneous movement of a large number of atoms. A correspondingly large number of atomic cohesion "bonds" must be broken at one time. The result is that the strength (or what is the same thing, its elastic limit in shear) of a crystal is definite. The cohesion bonds in an amorphous material may be broken very gradually—almost one atom at a time, we might say. The force required to produce deformation is therefore very small. Such small forces must of course act for considerable periods of time in order to effect appreciable deformations.

There is a distinct and important time effect in the rupture of metals at high temperatures. At any given temperature which lies well above the annealing temperature of the metal but not too close to the melting point, either intergranular or transcrystalline fracture can be produced at will by varying the rate of applying the load. This is illustrated by some tests carried out on copper wire at a temperature of 950 deg. C.⁴

Time Required to Break	Tensile Strength	Type of Fracture
1 minute	710 lb. per sq.in.	Intergranular, brittle
5 seconds	2500 lb. per sq.in.	Transcrystalline, ductile

It will be noted that not only is the type of fracture changed by increasing the rate of loading but the strength is very greatly increased. This is explained on the assumption of an amorphous intercrystalline cement by the known properties of solid amorphous materials. Attention has already been called to the fact that glass will flow under its own weight acting for a long period of time, whereas it is perfectly elastic up to a stress of perhaps 30,000 lb. per sq.in. under loads acting for short periods. The typical combination of fluidity and hardness possessed by amorphous solids is perhaps illustrated even better in the properties of pitch. At ordinary temperatures pitch can be pulverized by means of hammer blows. If the particles of powder thus produced are put in a receptacle the force of gravity alone is sufficient to weld them into a single coherent mass of pitch. This welding may require considerable time, but it is so effective that even the air bubbles are slowly forced to the surface. Pitch can be deformed into any shape desired if sufficient time is taken. A barrel of pitch, for example, can be emptied by allowing it to flow very slowly from a small hole. At any time during this process of flow, a sharp hammer blow will shatter into fragments the stream of flowing pitch. Pitch is thus either hard and brittle or soft and plastic according to the rate of deformation attempted. Resistance to rapid deformation is very great, but deformation can be effected slowly by extremely slight forces.

Now the crystalline grains of a metal are supposed to be held together by an amorphous metal cement whose

properties at high temperatures resemble those of pitch at ordinary temperatures. At the freezing point of the metal the liquid or amorphous metal has practically no resistance to deformation. At the same time the crystalline metal has very considerable resistance to deformation. The case is similar to that of water and ice at the freezing point of water. As the metal cools, the undercooled liquid or amorphous metal at the grain boundaries increases in viscosity so that at very low temperatures it has great hardness. At the same time the hardness and strength of the crystalline metal increase, but at a less rapid rate. At "high temperatures," which in the case of metals means at temperatures above that of recrystallization, the amorphous metal is softer than the crystalline.

Suppose a piece of metal such as the copper wires mentioned above be subjected to a small tensile load which is insufficient at the temperature of the test to deform the crystalline grains (the force required to deform a crystal is practically independent of any time effect). If this small load is allowed to remain on the test specimen, it will in time cause flow in the viscous amorphous cement and the grains will finally be pulled apart, without having themselves undergone any deformation. The fracture will then be of the intergranular, brittle type.

Suppose a similar specimen to be loaded rapidly to a much higher stress. The amorphous cement will sustain high stresses for short periods of time, so that if the load is applied rapidly enough, a stress can be reached which is high enough to deform the crystalline phase. Fracture will then take place through the grains instead of between them, and will be accompanied by considerable general deformation of the piece as a whole.

HYPOTHESIS OF AMORPHOUS METAL CEMENT

This is in brief the amorphous metal cement hypothesis as proposed by Rosenhain. It was advanced primarily to account for the cohesion between the grains of a metallic aggregate and the changes in cohesion with change in temperature. The development of the hypothesis leads, of course, to conclusions regarding other phenomena, particularly hardness. The amorphous metal at the grain boundaries was supposed to be the same as that proposed by Beilby as the cause of the hardness produced by cold deformation. Any increase in grain boundary surface must therefore result in an increase in hardness. This afforded a ready explanation of the fact that the hardness of metals increases as the grain size becomes smaller. Carrying the idea to the extreme, Rosenhain proposed that the great hardness of hardened steel is due to "the presence of an extremely minute network of amorphous layers" surrounding the very fine grains of alpha iron which result from the rapid transformation of gamma iron. He regarded the amorphous iron as being especially hard in this case because of iron carbide in solution.

Beilby's theory of hardening by the formation of amorphous metal and Rosenhain's conception of an amorphous intercrystalline cement comprise what may be called the fundamental ideas of the amorphous metal hypothesis. These ideas have in some form gained a rather wide acceptance in England and America, although they have not been so favorably received on the Continent. There is at present no unified opinion regarding the details of the hypothesis, which is quite to be expected considering its newness and its speculative nature. It must be recognized that this hypothesis

⁴See references and footnotes on page 704.

concerns some of the most important properties of metals and therefore deserves very careful inquiry and consideration both as to the fundamental ideas and their detailed development.

CAN METAL BE PRODUCED ENTIRELY AMORPHOUS?

The first question to be considered should perhaps be that of the reality of amorphous metal. It is possible by means of the X-ray spectrometer to literally "look into" a metal and recognize the presence of crystalline material. Unfortunately, however, there is no such positive test for the presence of amorphous material. The most direct proof of the reality of amorphous metal would of course be the production of metal *entirely* in the amorphous condition. Beilby attempted to do this by mechanical deformation and he selected wire-drawing as a suitable process because of its drastic nature. After having drawn wires of silver, copper and gold to as much as fourteen times their original lengths, he concluded that they still contained crystalline metal and that it is impossible by mechanical deformation to convert a metal entirely into the amorphous modification. In addition to the microscopic observations upon which his conclusion was largely based, there is an abundance of confirming evidence of a more positive nature.

Beilby considered that he had produced a totally amorphous mass of metal by compressing very fine gold powder precipitated from aqueous solution. He described his product as harder and less plastic than other forms of gold, and also resistant to recrystallization at 350 deg. C., or about 100 deg. C. above the temperature required for the recrystallization of cold-drawn gold wires, a property he attributed to the absence of crystalline nuclei. It is now known that chemically precipitated metallic powders, even when composed of the finest particles, are perfectly crystalline, so that masses formed by compressing them are themselves predominantly crystalline.

It is quite certain that no totally amorphous mass of solid metal has been produced. A little consideration of the molecular structure of amorphous bodies is interesting in this connection. The materials which are most readily obtained in amorphous form, such as pitch, glass and vitreous silica, always have several atoms to the molecule. Some of the chemical elements, of which sulphur is an example, can also be obtained in an amorphous condition. A sulphur molecule contains eight atoms. Metals are monatomic in all conditions of aggregation and therefore crystallize more freely. A single atom can obviously find its place in a crystal lattice more easily than can a molecule containing several atoms. It will therefore be very difficult to obtain metals in an entirely amorphous solid state.

POSSIBLE STRUCTURES AT GRAIN BOUNDARIES

The best evidence for the existence of amorphous metal is probably to be found in the conditions at grain boundaries. In the original statement of their inter-crystalline cement hypothesis Rosenhain and Ewen advanced the idea that the crystallization of metals takes place by the addition of crystal units containing large numbers of atoms. In the region where two crystals abut against one another—that is, at the grain boundaries—there would have to be some metal which could not attach itself to either crystal because of being too small in amount to form crystal units. Furthermore, since the crystalline grains have different orientations, the units or blocks of one would not fit

in with the blocks of the other, and interstices of irregular shape would be left which could not be filled up with other crystals no matter what their orientation. The metal remaining in these interstices must then retain the structure of the liquid—i.e., must be amorphous.

The diagram in Fig. 1 shows this condition in a schematic way, the shaded areas representing the interstices filled with amorphous metal.

This conception is no longer tenable, inasmuch as it now appears quite certain that the "crystal units" consist of one atom each. The actual conditions must nevertheless be very similar, in a qualitative way and on a smaller scale, to those represented in the diagram.

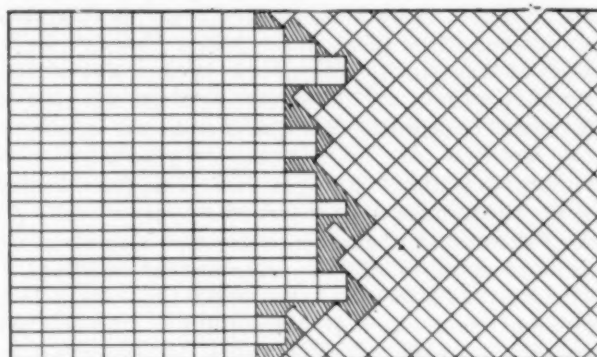


FIG. 1. HYPOTHETICAL CONDITION AT GRAIN BOUNDARY (ROSENHAIN AND EWEN²)

Certainly where two crystals of different orientation meet it is not geometrically possible for all of the atoms present to have places in an undisturbed space lattice without leaving some voids.

There are three possible conditions: (1) There are voids between the two crystals; (2) there is a zone in which some of the atoms are held in *both* crystal lattices, in which case the lattices would be distorted at the surface of contact; or (3) there is a zone of disorganized or *amorphous* metal.

There is no way known at present of determining the actual structure at the grain boundaries of metals. It is certain that, under various conditions of temperature and rate of loading, metals behave as they would if their grains were held together by a cement of a substantially amorphous nature. There are many other properties of metals which are consistent with the assumption of an amorphous cement, and none, to the author's knowledge, which are inconsistent. The hypothesis is thus plausible from the structural viewpoint and logical in that it offers satisfactory explanations of the properties of the grain boundaries of metals. This is enough to justify the utilization of the idea as a working hypothesis—but we can go even further. The amorphous metal cement hypothesis is at the present time the *only* satisfactory explanation of the effect of temperature and rate of loading on the strength and manner of rupture of metals. This fact confers upon it an added degree of probability.

IMPURITIES AT BOUNDARIES

The only alternative theory that has been advanced is based upon the assumption that even in what are ordinarily termed "pure" metals there are appreciable quantities of impurities forming eutectics melting below the melting point of the metal. When the metal is heated to high temperatures, these eutectics melt and

form molten layers around the grains of solid metal. The molten layers have very little strength and hence allow the grains to be pulled apart on the application of small loads. There are a great many objections to this explanation. The phenomena to be explained occur with great distinctness in metals of the very highest purity. Any eutectic that might be present in such a pure metal would necessarily have a very high melting point, little short of that of the theoretically pure metal. In any case the melting point of the eutectic would be fixed. This is not the case with the temperature separating intergranular from transcrystalline fracture, which varies with the rate of loading or duration of load. Furthermore, intergranular fracture can be produced at any temperature from the recrystallization temperature to the melting point. The intergranular eutectic hypothesis is untenable from this point of view. An additional objection is that it does not sufficiently explain the time effect, especially on the tensile strength such as quoted on p. 699 for copper.

In the authors' opinion it is justifiable to conclude that the metal at the grain boundaries is or simulates an amorphous material. It is not possible to reach any definite conclusions regarding the degree of disorganization of this material or the thickness of the films around the grains. Although definite information on these points is desirable, it is not necessary to the formulation of a useful theory. The essential fact is that the grain boundary metal possesses mechanical properties like those of a vitreous amorphous substance.

The amorphous cement occupies a very important place in the structure of metals, inasmuch as it is continuous. Nevertheless, the amount of crystalline metal is so preponderant that as a rule metals never exhibit properties like those of an entirely amorphous material. In the tests of metals at high temperatures which have

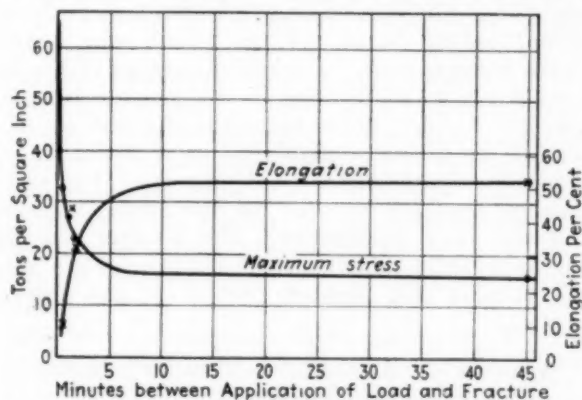


FIG. 2. EFFECT OF RATE OF LOADING ON ZINC-ALUMINUM-COPPER ALLOY (ROSENHAIN, HAUGHTON AND BINGHAM)

been referred to, the tensile strength varies with the rate of loading in the same manner as that of an amorphous material. That is, the longer the time taken in breaking the specimen the smaller the load required. The elongation, on the contrary, follows an exactly opposite course. Metals broken by small loads acting for long periods of time show little if any elongation while an amorphous material like pitch or glass (at a red heat) shows more elongation the slower the loading.

ZN:AL:CU ALLOY OF PECULIAR PROPERTIES

An alloy has recently been described which is of special interest for the reason that both its strength and its ductility are affected by the rate of loading in

the same manner as are those of amorphous materials. The alloy is the ternary eutectic of zinc (89 per cent), aluminum (7 per cent) and copper (4 per cent). The principal metal, zinc, recrystallizes at room temperature so that the "high-temperature" phenomena of less fusible metals like iron are in this case obtained at ordinary temperatures. The properties are shown best by the alloy after it has been subjected to considerable rolling at about 250 deg. C. A strip of the metal in this condition can be bent double between the fingers, if the bending is carried out slowly, taking, say, five minutes. An attempt to bend the strip quickly causes it to break

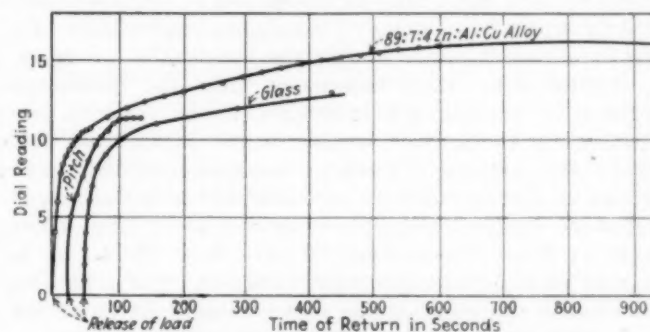


FIG. 3. RETURN FLOW OR CREEP IN RECENTLY DEFORMED ZINC-ALUMINUM-COPPER ALLOY, PITCH AND GLASS (ROSENHAIN, HAUGHTON AND BINGHAM)

with a sharp snap. This is exactly the behavior that would be expected of an amorphous material like pitch. This simple experiment demonstrates in a qualitative way the effect of rate of loading on the properties of this alloy. A quantitative expression of the same effects is found in the curves reproduced in Fig. 2.

This alloy resembles amorphous materials in another respect—namely, the return flow or "creep" after deformation. If a strip of amorphous material like pitch is bent in a given direction and then released, it springs back somewhat in the opposite direction, but does not immediately assume a stable position. It continues to creep back slowly at a steadily diminishing rate. All metals with the exception of single crystals behave in a similar manner, but the creep is usually so slight that rather sensitive instruments are required to detect it. Rosenhain's alloy exhibits this property to a degree comparable with pitch. The curves in Fig. 3 show the return creep for three materials, plotted to the same scale except that for glass the deformations are magnified $14\frac{1}{2}$ times.

The exceptional degree to which this alloy resembles materials that are entirely amorphous is attributed by the present authors to a very fine grain size stable at temperatures normally in the recrystallization range. The alloy consists of the three structural constituents of the ternary eutectic. These crystalline constituents are divided very finely by the rolling process. Grains of a pure metal broken up in this way by deformation carried out above the recrystallizing temperature promptly unite so that the metal is left in a moderately coarse-grained condition. In this case, however, the eutectic constituents cannot unite, and by interfering with grain growth in the matrix (zinc) cause the final grain size to be very small. This, coupled with the probable high specific hardness of the crystalline constituents, accentuates the effect of the properties of the grain boundary metal. The discovery of the properties of this alloy is important, because this is the

only case on record in which the properties of the amorphous "phase" completely mask those of the crystalline constituents in a metallic aggregate.

OTHER PROPERTIES OF GRAIN BOUNDARIES

There are many phenomena for which the amorphous metal cement hypothesis furnishes a convenient explanation, but for whose explanation the assumption of an amorphous cement is not necessary. They are therefore not to be regarded as strong evidence for the existence of an amorphous metal cement, but merely as facts which are consistent with the hypothesis. One group of such facts may be comprised in the statement that the grain boundaries of metals are particularly subject to chemical attack and to the penetration of gases. A bronze can be disintegrated into its individual crystals by the action of mercury (Desch),⁶ which dissolves away the grain boundary metal. Dickenson⁷ has shown that certain failures of manganese bronze were caused by the penetration of solder between the grains while the metal was under tensile stress. The solder must of course be molten to have this effect. It is usually necessary in this as in other cases of a similar nature for the metal to be under tension in order for any rapid intergranular penetration to take place.

Cold-worked articles of brass, such as cartridge cases, are subject to a type of failure known as "season cracking." After standing for some time, perhaps years, the article develops cracks which are shown by microscopic examination to be intergranular. It has been shown that season cracking can take place in the entire absence of corrosive agencies. There is no doubt, however, that corrosion either by the atmosphere or by other agencies greatly hastens the process. Brass articles are often tested for susceptibility to season cracking by immersion for a short time in a solution of mercurous nitrate. Metallic mercury is liberated and penetrates the grain boundaries of the brass where tensile stress exists. Cracking then follows quickly.

In the carbonizing of steel the carbon penetrates by way of the grain boundaries. The penetration is probably largely due to an actual penetration of carbon monoxide gas, although it is partly due to diffusion of carbon from the surface. This diffusion also follows the grain boundaries, as can be seen by reheating a graphitized iron to temperatures above the critical and then cooling rapidly.⁸ The carbon will be found to have been reabsorbed into the iron by way of the grain boundaries.

Commercially pure copper is embrittled to a ruinous extent by annealing in a reducing atmosphere, such as hydrogen. The hydrogen is supposed to penetrate the metal and reduce the copper oxide which is always present. The steam formed is unable to escape and its disruptive force is the cause of the bad effect on the copper. In this case again the penetration of the hydrogen takes place partly by way of the grain boundaries.

Many other examples could be cited to illustrate this susceptibility of the grain boundaries to attack. It is to be assumed that the amorphous cement supposed to exist at the grain boundaries is electro-positive to the crystalline metal, since it more closely resembles the liquid in structure and therefore has a higher internal energy content. This would account for its greater susceptibility to chemical attack and penetration by molten metals. The penetration by gases would be ascribed to the freedom of motion of the atoms in the amorphous metal, which would not present a rigid

barrier to the penetration of gas molecules as would the fixed atoms in the crystal lattice. These facts can also be explained on the assumption that the structure at the grain boundaries of metals consists of two perfect crystal lattices interlocking with the formation of voids free from any amorphous metal.

"VACUUM ETCHING"

Another phenomenon closely allied to these is one known broadly as "vacuum etching." Rosenhain and Ewen sought to demonstrate the existence of amorphous metal at the grain boundaries by determining the relative losses in weight of coarse- and fine-grained metals when heated in vacuo. They showed that the losses of the fine-grained specimens were much greater than those of the coarse-grained specimens, and attributed this to the presence of greater quantities of amorphous metal, which is quite logically supposed to have a higher vapor pressure than the crystalline metal. These observations are, however, explained with equal satisfaction on the basis of any of the three possible grain boundary structures mentioned above.

Special attention has been called by one of the authors⁹ to the flow of metals at high temperatures. In making filaments for certain classes of electric lamps, it is desirable to have tungsten wire which will not sag under its own weight when heated to high temperatures. It has been found that at high temperatures fine-grained wires sag much more than do coarse-grained wires. This is consistent with the theory that the sagging consists in *flow* in the layers of amorphous cement around the grains. Small grains would lead to greater flow because of more grain boundary surface. An alternative explanation is that the sagging of the wires consists in a migration of the grain boundaries—that is, grain growth—under the influence of stress and temperature. Such grain growth would take place in a direction tending to relieve the stress, which would cause the wires to sag. The greater sagging of the fine-grained wires would be due to the greater boundary surface and to the greater tendency of small grains to grow. It is probable that this is a factor in the observed flow (although not the only one), but such a mechanism does not account for the strength properties of the grain boundaries. The authors therefore prefer to consider that the grain boundaries are amorphous, because this accounts for all of the observed properties.

AMOUNT OF AMORPHOUS METAL PRODUCED BY COLD-WORK

The question of the formation of amorphous metal during plastic deformation is perhaps more difficult than that of its existence at grain boundaries. There is again no direct evidence and there are in this case no phenomena which cannot be explained without assuming the formation of amorphous metal on all of the slip planes. Beilby advanced his hypothesis primarily as an explanation of hardening. It is the opinion of the present authors that hardening can be satisfactorily accounted for on the basis of a rearrangement of crystalline material, as described in a previous article.¹⁰ Any amorphous metal formed would of course contribute to the hardening, but it is not necessary to assume its presence for this purpose.

Beilby's hypothesis was, as indicated above, based largely on his studies of polished surfaces. Having concluded to his satisfaction that the surface layers of

polished metals are in an amorphous condition, he assumed that the internal friction on slip planes during deformation also generates layers of amorphous metal. There is some doubt that the surface layers of polished metals are entirely or even largely amorphous, but even granting that they are entirely amorphous, this cannot be considered as more than a suggestion that similar layers are formed on the internal surfaces of slip. The processes—polishing and slip—differ in two important respects. The friction in polishing is between the metal and a dissimilar surface, usually a cloth charged with fine particles of hard metallic oxide. Secondly, the amount of relative motion between the two surfaces in the case of polishing is enormously greater than in the case of crystalline displacement by slip.

BEILBY'S ORIGINAL HYPOTHESIS IMPOSSIBLE

A rough calculation will suffice to show that Beilby's hypothesis as originally proposed is impossible. According to this hypothesis, as well as the ideas prevailing among its adherents in England and America at the present time, amorphous metal is developed at *each* slip plane and slip occurs only *once* on each plane. From many observations of slip bands, made mostly on fairly coarse-grained specimens, it appears that the maximum extent of motion along a slip plane during a single deformation ranges from 1,000 to 5,000 atom diameters, seldom greater. It also appears that the extent of slip is less the smaller the grain size. Normally, therefore, the average extent of a single slip is probably well under 1,000 atom diameters. Assume, for example, a single crystal in the shape of a 1-in. cube, of a metal having 100,000,000 atoms per linear inch. Assume that slip generates amorphous layers two atoms in thickness, which is about the minimum that could be considered amorphous. The number of possible slip planes on the cross-section would then be 50,000,000. A slip on each of these planes to an extent of 1,000 atom diameters would result in a general extension of 500 in., after which all of the metal would be amorphous.

But copper can be extended by cold-swaging and drawing, without intermediate annealing, to as much as 5,000 times its original length and the metal is still preponderantly crystalline! Tungsten wire drawn to 200,000 times its original length without intermediate annealing still gives perfect X-ray patterns, showing that it is predominantly crystalline! Beilby's scheme of plastic deformation is not consistent with such facts.

The wires of copper, silver and gold with which Beilby experimented were in no case drawn to more than fourteen times their original lengths, and he stated that the maximum strength was reached after drawing to from three to five times the original length. This increased strength and hardness he attributed to the formation of layers of amorphous metal, yet the proportion of metal converted to the amorphous condition would not have to be so very large. The greatest possible proportion actually so converted in his wires may be judged by the fact that wires drawn one thousand times as much are still predominantly crystalline. We believe, therefore, that any amount of amorphous metal that may be produced by drawing a wire to five times its original length could not in itself be responsible for the increased hardness and strength.

The abundance of crystalline material left in a cold-drawn wire is further shown by the fact that wires drawn until they have lost practically all of their ductility when tested at ordinary temperatures regain their

ductility to a large extent on cooling to the temperature of liquid air. Ductility is at low temperatures dependent on the presence of a very considerable amount of crystalline metal, since amorphous metal is considered to become increasingly hard and brittle as the temperature is lowered.

The evidence shows that whatever amorphous metal may be formed during cold deformation is very much less in amount than indicated by Beilby and generally held by the adherents of his hypothesis. It follows that the importance attached to the specific hardness of amorphous metal as the cause of hardening has also been greatly exaggerated.

WHAT CAUSES A SLIP TO HALT?

The conclusion that there are not formed on *all* of the surfaces of slips vitreous amorphous layers which prevent further slip on those surfaces does not preclude the possibility that some amorphous metal is produced during plastic deformation. A little consideration will show us that the block movements on slip planes, or "slips," may be divided into two rather distinct classes.

When a single crystal of metal is broken in tension, it might be expected that the final failure would take place on the first plane on which slip occurs. Such, however, is not the case, since large single crystals of ductile metals are themselves ductile and draw out under tension into the form of wedges. This shows that failure does not occur on the first slip plane. We must conclude that something happens during the process of slip which causes the resistance to further slip on that plane to be *greater* than the resistance to the starting of slip on some new plane. The slip may be said to be "self-stopping."

In ordinary pieces of metal which are aggregates of many small grains it is probable that only a small proportion of the slips are self-stopping. The majority of the slips are brought to rest by end resistance. There is every indication that the resistance to further movement on the surfaces of such slips is *less* than the resistance to the starting of slip on a new plane. At the beginning, therefore, a slip plane is a surface of weakness.

All this amounts merely to saying that a certain amount of *movement* or of *time*, or both is required for the building up of resistance on a slip plane. The "weakened and building-up" stage corresponds to the "mobile" state of Beilby. It may be that amorphous metal is actually in process of formation in this stage. The later stage when the slip has become self-stopping undoubtedly represents an altered structural condition at the surface of slip, which must necessarily involve some local disorganization of the crystalline metal. This disorganization may or may not be sufficient in kind and depth to justify the assumption of *vitreous* amorphous layers. The indications are that the disturbance does not penetrate very deeply and also that the differences in orientation between two adjacent crystal fragments are never very great. *Certainly the surface condition at slip planes even in the self-stopping stage does not prevent further movement on the same surface.* In the first stages of slip there is no reason to assume the presence of any amorphous metal, and in the later stages it is not justifiable to assume the presence of vitreous layers so rigid as to prevent further slip.

At the grain boundaries the conditions are different. The shapes of the original grains must change in a manner depending on the change in shape of the piece

of metal taken as a whole. No matter what the direction of extension, the grain boundary surface is increased by cold-work. Each slip intersecting a grain boundary produces one "lapped-over" fragment the surface atoms of which may be utilized to increase amorphous metal at the grain boundary. As deformation becomes severe, the grain boundary layer of amorphous metal should become thicker by the same process. It is the authors' opinion that the chief generation of amorphous metal by cold plastic deformation occurs here.

SUMMARY

1. Certain properties of cast metals or metals which have been worked and annealed are satisfactorily explained only on the assumption that the metal at the grain boundaries is in a substantially amorphous condition.

2. There is not at present sufficient evidence to determine whether this grain boundary metal possesses the perfectly amorphous structure indicated by the term *vitreous*. There is, however, enough evidence to justify the assumption that the grain boundary metal possesses the essential deformational and strength characteristics of typical vitreous amorphous materials.

3. The hypothesis that crystalline grains of metal are cemented with amorphous metal—i.e., the amorphous metal cement hypothesis—is not inconsistent with any of the known properties of metals.

4. Plastic deformation at temperatures below the temperature of recrystallization generates additional amorphous metal at the boundaries of the original grains.

5. There is no means of estimating with any exactness the quantities of amorphous metal which may be present under various conditions. There is certainly more amorphous metal in severely cold-worked metals than in annealed metals. Even the most severely cold-worked metals are predominantly crystalline. The amorphous metal hypothesis is a qualitative rather than a quantitative conception, so that it is perhaps not necessary to form very definite ideas as to the possible quantities of amorphous metal.

6. The formation of vitreous amorphous metal at all the internal surfaces of slip in the manner postulated by Beilby is not possible, and the hardness produced by cold-working can be readily explained without the assumption of such amorphization.

7. There is developed on some of the surfaces of slip a condition of cohesion greater than that in the undeformed crystal. This condition may presumably be due to a locally disorganized structure, but the assumption of a layer of *vitreous* amorphous metal is not necessary nor is it consistent with all of the facts.

8. Whereas the amorphous metal theory of deformation postulates that when slip has once occurred on a particular plane, no further slip on that plane is possible, the evidence available indicates not only that further slips on a "used" plane are possible but that they *must* occur in the course of the maximum deformation that can be effected.

9. The conception of an intergranular amorphous metal cement furnishes a very good explanation of certain deformational and strength properties of metals and a very useful working hypothesis. The importance attached to the specific hardness of amorphous metal as a cause of hardening has been greatly exaggerated.

REFERENCES AND FOOTNOTES

1. "The Hard and Soft States in Metals," G. T. Beilby, *Jour. Inst. Metals*, No. 2, 1911, pp. 5-43.

2. "Intercrystalline Cohesion in Metals," Rosenhain and Ewen, *Jour. Inst. Metals*, No. 2, 1912, pp. 149-185.

3. "The Slip Interference Theory of the Hardening of Metals," Zay Jeffries and R. S. Archer, *CHEM. & MET. ENG.*, vol. 24, p. 1067, June 15, 1921.

4. The conception of an amorphous cement between the grains of metals was published practically at the same time by Bengough (*Jour. Inst. Metals*, No. 1, 1912, pp. 123-190) and by Rosenhain in a discussion of Bengough's paper.

5. It was Bengough's view that the amorphous cement disappeared entirely at high temperatures and that the intergranular fractures were due to the absence of any cementing material. Rosenhain's view that the lessening of the cohesion between the grains is due to the softening rather than the disappearance of the amorphous metal was considered preferable by Bengough and is now generally accepted by the adherents of the amorphous metal theory.

6. "Effect of Temperature, Deformation and Grain Size on the Mechanical Properties of Metals," Zay Jeffries, *Trans. Am. Inst. Min. Engrs.*, vol. 60, pp. 474-562.

7. "Zinc Alloys With Aluminum and Copper," Rosenhain, Haughton and Bingham, *Jour. Inst. Metals*, No. 1, 1920, pp. 261-317.

8. "The Solidification of Metals From the Liquid States," Desch, *Jour. Inst. Metals*, No. 2, 1919, pp. 240-263; *CHEM. & MET. ENG.*, vol. 21, p. 773 (Dec. 24, 1919).

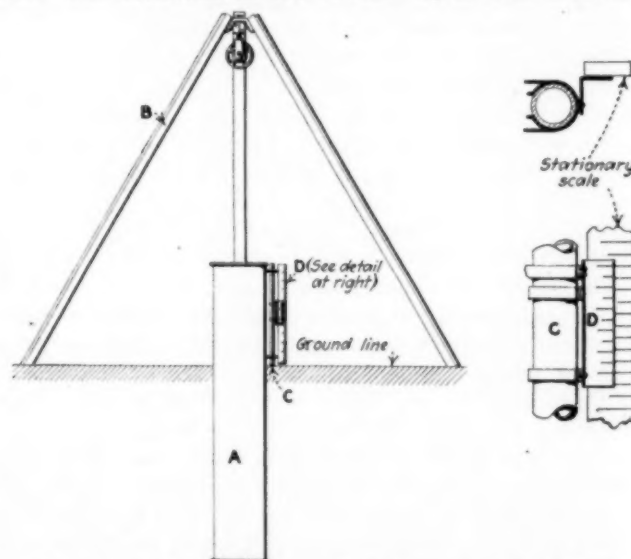
9. See reference 8, discussion by Dickenson.

10. "Graphitization of White Cast Iron," R. S. Archer, *Am. Inst. Mining Engrs.*, February Meeting, 1920.

11. "The Amorphous Metal Hypothesis and Equi-Cohesive Temperatures," Zay Jeffries, *Trans. Am. Inst. of Metals*, 1917, p. 300.

Volumetric Measurements of Pulpwood

In making pulpwood measurements and yield determinations it is often desired to ascertain the solid contents of a piled cord. The apparatus used for that purpose at the Forest Products Laboratory consists of (A) a galvanized tank set in the ground, with a volume of about 1.75 cu.ft. per ft. of length; (B) a tripod placed over the tank for raising and lowering the heavier sticks; (C) a glass gage on the side of the tank, calibrated to read in cubic feet and decimals thereof; and (D) a simple vernier scale attached to the glass gage to permit closer reading to five thousandths of a cubic foot. Ten divisions on the vernier equal nine divisions



on the stationary scale. Graduations on the stationary scale are in tenths and five hundredths of a cubic foot.

Before immersing each stick, the water level in the gage should be at or slightly above the zero mark. The stick is immersed and held just below the surface of the water by a pointed rod stiff enough to overcome the buoyancy of the largest and driest pieces without bending. One gage reading is made before and one after the immersion of the stick, the difference giving its volume.

The Fine Art of Lime Burning*

Complete Mechanical Handling of All Materials and Precise Technical Control of All Operations Have Been Provided For in the New Plant of the Rockland & Rockport Lime Corporation
—Crushing Plant—Kilns—Charging Equipment—Storage and Packing

BY GEORGE B. WOOD†

EACH individual limestone requires its own peculiar heat-treatment to produce a lime of desired qualities. A certain limestone, for example, may best be hard-burned slowly at low temperature for furnishing lime to a causticizing plant. It may best be light-burned at low temperature for building lime and it may best be light-burned quickly at high temperature for lime to go to the hydrating plant.

Dr. Holmes, of the Lime Association, is undoubtedly going to discover a lot of valuable truths along these lines, but such knowledge will profit us little until we build lime-burning plants capable of operating under stabilized conditions of physical and chemical control.

With these requirements in mind, as well as maximum heat efficiency and minimum labor operating costs, what should we demand of the modern limekiln?

1. Continuous mechanical feed of rock and continuous mechanical discharge of lime. When lime is properly burned it should be immediately taken away, not left to soak in the heat and gases for four to six hours.

2. Positive control of temperature.

3. Positive control of draft.

4. Positive control of burning period and lime discharge.

5. Positive control of combustion.

6. Minimum temperature of flue gases and cool lime ready for immediate handling and shipment as it leaves the kiln.

The new plant at Rockland, now nearing completion, is capable of meeting all of these requirements and based on the results of an accurate test with our stone will undoubtedly show a saving of 50 per cent in labor cost and very probably a saving of 50 per cent in fuel consumption over the former old-fashioned methods with hand-fired kilns.

ROCK-CRUSHING PLANT

The first requirement for maximum efficiency and uniform quality is uniform-sized stone going into the kiln. Our new rock-crushing plant at the quarry (Fig. 1) is not unique in any particular feature except for provision in the storage bin of three separate compartments, making possible three different classifications of quality of rock going to the kilns. The plant consists of a 48 x 42-in. Traylor jaw crusher set entirely below grade, permitting a trainload of rock (twenty-five to thirty 4-yd. standard-gage dump cars) to run down by gravity, dumping one car at a time into the crusher. An air hoist facilitates dumping of cars and an electric car puller starts the train whenever cars fail to move by gravity. Each car holds between 5½ and 6 tons of rock, and we recently dumped through the crusher as a

test twenty-five cars in 22 minutes. A pan bucket elevator 84-ft. centers with buckets 42 in. wide carries the rock to the top of the structure, where a shaking grizzly separates the 3-in. and smaller stone from the kiln stone. A revolving screen and a small auxiliary gyratory crusher sizes small stone for the crushed stone market. A 14-in. belt conveyor 100 ft. long, discharging into an abandoned quarry, disposes of the surplus fine stone when there is not a market. This spill conveyor

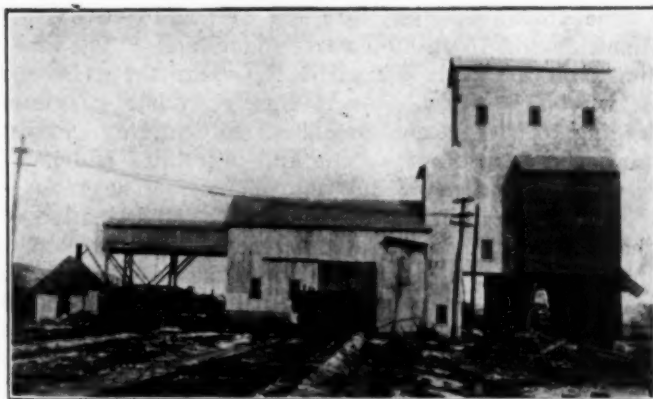


FIG. 1. ROCK-CRUSHING PLANT

eliminates all the additional handling cost in winter time from small stone frozen solid in bins and cars. The storage bins hold a total of 900 tons of the various sized stone and discharge from the bottom and the side into cars on two loading tracks. All machinery is electrically driven.

LOCATION AND SHIPPING FACILITIES

The kilns, hydrate mill, barrel factories and warehouses are all located at the waterfront of Rockland harbor, and the quarries are situated a mile and a half inland. The lime company owns and operates a standard-gage steam railroad, a belt line around the city which is a switching terminal and feeder for the Maine Central R.R. Coal and coopersage stock are received by water, lime is shipped by both rail and water and the Lime Rock R.R. distributes rock and coal and handles all the freight cars for the various plants. The railroad has 13 miles of main line and sidings, four locomotives and 495 4-yd. dump cars which are maintained and repaired in the company's own shops.

With this explanation of plant conditions, it will be understood why we have adopted at the new kiln plant a rather new and unusual method of rock storage and kiln-charging machinery.

LIMEKILNS

The new lime plant comprises a battery of six Mount kilns with two Morgan mechanical producers centrally located and one horizontal tubular boiler. The plant is

*Paper presented at the third annual convention of the National Lime Association, New York, June 16, 1921.

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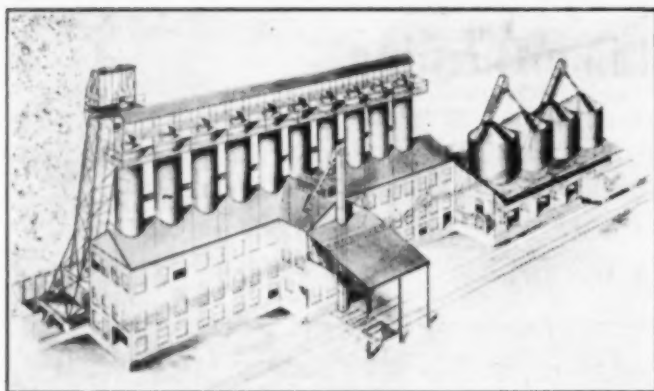


FIG. 2. GENERAL ARRANGEMENT OF LIME PLANT

designed with provision for two additional kilns at either end to make a future battery of ten kilns. The ultimate extension of the plant is indicated in Fig. 2. The boiler is fired with producer gas, but the setting provides for a mechanical coal stoker to be installed in the future when ten kilns are put on the two producers.

The kilns (see Figs. 3, 4 and 5) are 10 ft. outside diameter and 75 ft. high above foundations. The brick lining stops at a height of 55 ft., where the gases are drawn off by induced draft through waste gas flues leading to a duplicate system of motor-driven exhaust fans. The top 20 ft. of the kiln is unlined and holds a reserve storage of 45 tons of rock. The rock is charged through an air-tight charging bell at the top of the kiln, which is operated by compressed air. The draft of each kiln is regulated from the floor by a cable leading to a damper on the exhaust flue. Water-cooled valves regulate the flow of gas through tuyeres on two opposite sides of each kiln. Constant gas pressure is maintained at the producers by automatic regulators. Air for combustion is drawn from the bottom of the kiln through the hot lime below the fires, preheating the air before meeting the gas for combustion and thoroughly cooling the lime before it discharges from the kiln.

The lime discharges continually through an annular opening at the bottom of the cooling cone onto a slowly revolving circular table. The speed of the table determines the rate of discharge and may be regulated for each kiln independently through the simple shift of a lever. A 24-in. steel pan conveyor receives the continuous discharge of lime from all the kilns and carries it into the lime sorting and packing building.

The coal arriving at the plant is dumped from cars into a track hopper, where it is crushed and elevated by machinery into a 100-ton storage bin over the gas producers. The producers are fed and poked mechanically and also by machinery discharge their ashes at fixed intervals into cars spotted on a depressed railroad track which runs through the kiln building. Soot traps in the main gas flues also empty direct into cars on this track.

TEMPERATURE CONTROL OF KILNS

Each kiln is fitted with two pyrometers, one at the high-temperature zone and one at the top. A cabinet at each kiln contains the indicating instrument with a two-way switch as well as a draft gage permanently connected to the kiln. The high-temperature pyrometer of each kiln is also permanently connected by special cable to graphical recording instruments located in the superintendent's office. Thus the foreman on duty can at all

times note the temperature and draft readings of each kiln and make adjustments to maintain predetermined continuous operating conditions. Also the superintendent may look at the six continuous red ink lines on the chart in his office and know without doubt if the temperature went wrong on any of the kilns during the day or night.

TECHNICAL CONTROL OF KILNS

Here is the time to introduce the plant chemist and his three assistants, perhaps more properly termed chemical engineers. The assistant chemist on duty through an 8-hr. shift will be the cock of the walk. At fixed intervals he makes quick analyses of producer gas and flue gases, notes the kiln temperature and the lime and knows without guesswork what to do. By his

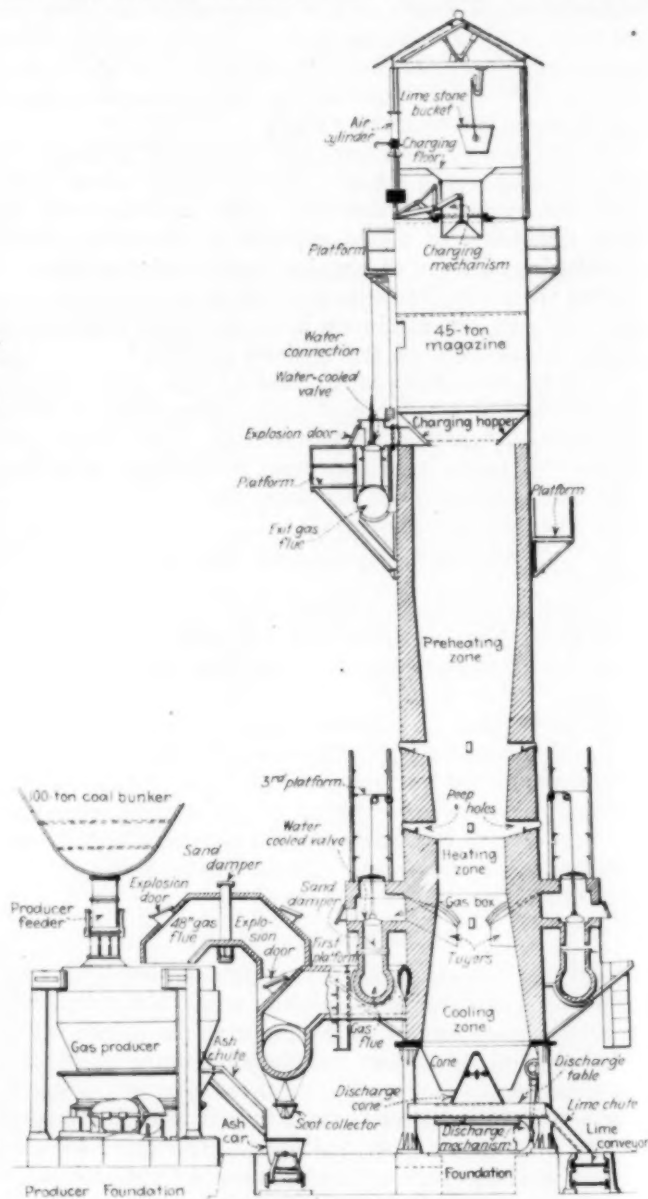


FIG. 3. MOUNT KILN IN SECTION

orders the boss kiln tender closes a gas valve here, opens a draft damper at some other kiln, speeds up the discharge of one kiln or slows down another. Again he may order the producer operator to speed up the coal feed on No. 1 producer or open the air damper on the blower of Producer No. 2. If draft conditions and flue gas analyses persist in acting queerly on Kiln No. 5, we may find the assistant chemist and the kiln boss looking

in the observation ports and finally discovering on the operating platform at the third level that the kiln is hung up on one side and must be barred down immediately.

Here, then, is a kiln plant that can almost talk if it is treated in the manner which it deserves.

Let us suppose there is a periodic shortage of cars, the lime bins are nearly full and we must slow up production. With this plant the temperature may be lowered and the discharge slowed down to operate the whole plant at one-half production. The lime may be somewhat different from that burned at high temperature, but it will be good lime, not like some we used to get when we had to plug the old-fashioned kilns. When

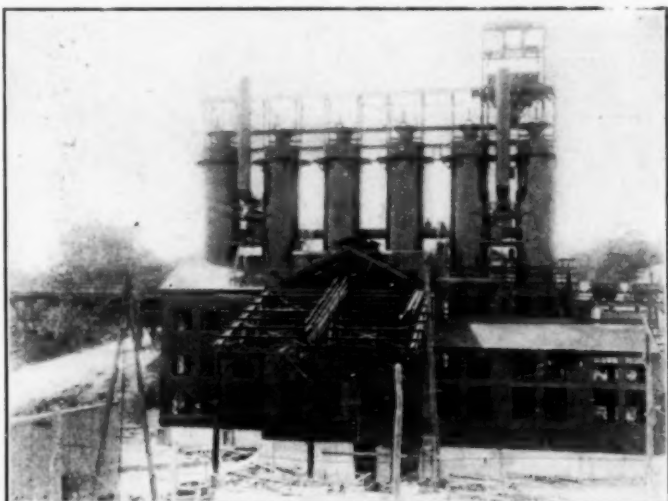


FIG. 4. KILNS UNDER CONSTRUCTION

cars come again in two days the young assistant chemist orders the temperature up, the drafts brought back and then the lime discharge gradually increased until early in the afternoon the plant is again in full swing at maximum production. Perhaps, however, just to romance a little, Kiln No. 1 is still kept at lower temperature because that kiln is filling an order for lime to the toothpaste trade and Dr. Holmes has very definitely determined that lime for this use should be burned under such conditions.

CHARGING KILNS

We will now go outside the kiln building and observe the method of charging rock into the kilns. This feature is perhaps the most unusual part of the new plant design. Consideration has been given to the fact that this plant is located near the residential section of the city and therefore in addition to no smoke there must be as little noise as possible, particularly during the night. Large rock storage provided at the kilns overcomes a temporary breakdown on the railroad system and the kiln-charging mechanism is designed for a ten-kiln plant with capacity to charge 700 tons of rock within an 8-hr. workday. The rock arriving in trainloads at the kilns is dumped from an overhead trestle into a side hill storage extending the full length of the kiln battery and capable of storing in the neighborhood of 3,000 tons. A concrete base and wooden bulkhead with discharge gates for each kiln forms the front wall of this continuous storage bin. Between this bulkhead and the kilns is located a traveling skip hoist (clearly shown in Fig. 5), which acts as a single mechanical charging machine for the entire battery of kilns.

This is a steel structure 105 ft. high, the base measuring 34 x 26 ft., counterweighted with concrete and supported on car wheels which travel on 80-lb. railroad rails. Electric hoisting and haulage engines, with automatic control, are located in a steel house on the base of the structure and power is taken from trolley wires attached to the kiln building. Two skip cars hung in balance travel on separate rails to the top of the structure, where they dump automatically into a common receiving bin discharging into the rock hopper of the kiln. Operation is entirely automatic from push button control. The operator on a platform at the base of the structure opens a rock gate and fills the skip on his right with 3 tons of rock, closes the gate and pushes a button. The skip travels to the top, dumps and stops, bringing the second skip to the bottom opposite the gate on his left. The operator fills the second skip, again pushes the button, and so continues until the kiln is filled. He then takes the handle of a controller and moves the whole structure as a motorman moves his trolley car along the rails, until it comes abreast the next kiln and another pair of gates in the rock bin. One man operating the machine and one man at the top of the kilns will constitute the labor necessary at the kiln plant to put 700 tons of rock into ten kilns. The machine will ordinarily travel the length of the row of kilns filling them in the morning and repeat the operation in the afternoon. The storage magazines in the kilns will keep them fed with rock from that time until the next morning.

The mechanical draft and mechanical operation of these kilns make it possible to burn the smaller sizes of stone from the quarry. This is true particularly with stone which does not fine up in burning, and we expect to be able to burn our Rockland stone in sizes down to as small as 2 in. If practical operation proves it advisable, the stone can be classified at the crusher plant and

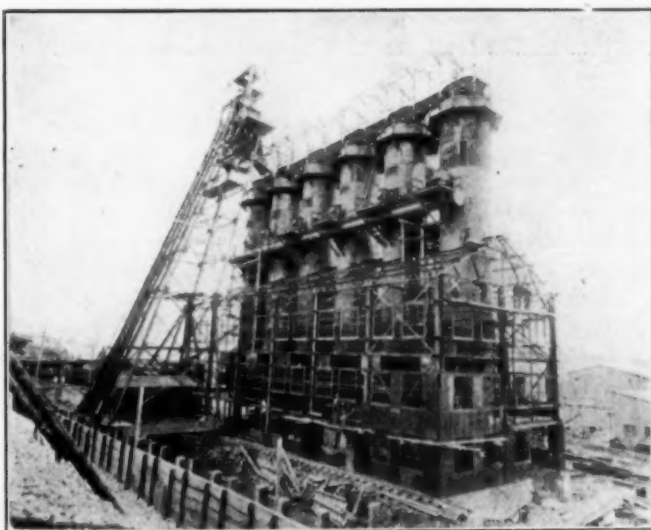


FIG. 5. TRAVELING SKIP HOIST FOR CHARGING KILNS

bin partitions provided at the kiln storage, making it possible to run certain kilns independently on certain sizes or certain quality of stone.

This completes the details of the lime-burning plant and we will now follow the lime on its course into the storage and packing buildings. Here we see how simplified the process may be when lime comes continuously and cool from the kilns instead of by periodic batches drawn hot onto a floor or into bins to cool.

The storage and packing building is a two-story fire-proof steel structure 108 x 60 ft. and adjoining the kiln building. As the lime conveyor enters this building it rises and discharges the lime over a bar grizzly, separating it into fines and lump deposited respectively onto two parallel pan conveyors which are elevated 3 ft. from the floor and act as a sorting table.

Here will be stationed one man on continuous duty for each 8-hr. shift, sorting into selected lump lime and common lime quality. The larger lumps are broken to remove possible core, black lime or possible brickbats are discarded and second quality lump lime is transferred from the selected side to the common lime side of the sorting table.

These conveyors discharge into bucket elevators, which carry the lime to the top of four overhead steel storage bins, each with a capacity of 500 tons. Two of these are shown under construction in Fig. 6. The storage bins are cylindrical, 25 ft. in diameter, with cone top and bottom. Special gates and shaking chutes discharge from the bins through the side of the building,

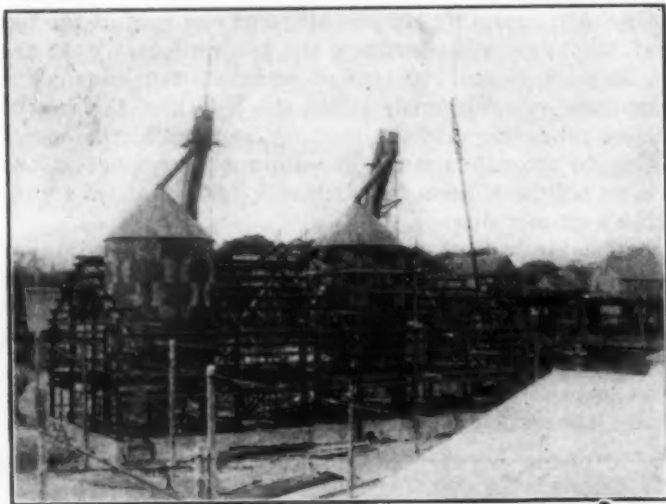


FIG. 6. LIME-STORAGE BINS

loading directly into box cars with a Pratt box car loader or directly into dump cars to go to the hydrate mill. Each bin has two barrel-filling chutes so designed that the operators may sort the lime as packing. This makes possible a second inspection of all lime filled into barrels.

The second story of the building is for empty barrel storage where one or two men are on duty to receive and pile new barrels from the barrel factory and to pass them into the feeding chutes leading to the lime packers on the lower floor. The lime packer takes each empty barrel from the chute, like taking a paper drinking cup, and fills it to required weight on a specially fixed counterweight scale. Trimmers put in the heads and trim the barrels and stevedores truck it direct into cars which may be spotted on railroad tracks at either side of the building. All lime will be packed only for immediate shipment except when anticipating rush shipments such as 7,000 large barrels to be loaded into a barge cargo for the New York market or 2,000 small barrels for a schooner shipment to Boston.

In such cases it is possible to store on the floor of the packing house 2,500 barrels at a time. Provision is being made to install at a later date a slow moving conveying platform which is level with the floor and follows a continuous rectangular course around the cen-

tral storage area. The man at the chute will fill a barrel with lime and place it on the moving platform, which immediately takes it out of his way. The trimmers will head up the barrels on the platform as it travels along and eventually the finished packages reach the desired place where they may be put directly into a car for shipment or onto the floor for storage.

Excepting the cases of emergency shipment, all packing and shipping will be daytime work six days a week. On Sundays and nights the lime goes into storage, the only men on duty being the eagle-eyed inspectors at the sorting table. There should be no loss from old lime air-slaking in barrels, and with storage capacity in air-tight bins for 2,000 tons of lime, the normal fluctuations of market demand should be discounted, making possible more uniform capacity operation of the kilns. All machinery is electrically driven with power bought at 2c. per kw.-hr. All the lime, coal and rock handling equipment was designed and furnished by the Link Belt Co.

Chemical Industry Power and Fuel Data

BY H. GOODWIN, JR.

THERE has recently been completed and shortly there will be issued the Report of a Superpower System for the Boston to Washington region. This has been made under the U. S. Geological Survey to determine the feasibility and economy of a "superpower" electrical system proposed to supply power to all at reasonable rates and to use waterpower to the fullest extent, by these two means conserving the nation's fuel resources.

The Bureau of the Census has co-operated in this by supplying data from the 1919 Census of Manufactures (soon to be published) prepared in a new and special form to facilitate analysis of the power and fuel requirements of each industry. The accompanying figures for the chemical industry will serve to supplement the general data given on p. 470 of the Sept. 7 issue.

POWER AND FUEL USED BY CHEMICAL INDUSTRIES

Table I gives a summary of the power and fuel used by the chemical and allied industries in the "superpower zone." The divisions are quite clear, but a few of the industries included under "all other chemicals" might be mentioned as follows: Acids, drugs, dyestuffs, fertilizer, ink, oils, paints, salts, soap, etc.

The column headings are self-explanatory except the next to the last column. On account of the great variations in the proportions of anthracite and bituminous coal used in the different industries, it was necessary to reduce them to common terms for comparative purposes. Most of the anthracite used is in the small sizes with low heating value. Further, boiler efficiencies are lower with anthracite than with bituminous coal. So it was determined that 1 long ton of anthracite as used in the industries is equivalent to 1 short ton of bituminous, and conversion was made accordingly to arrive at the total.

The total fuel used by all the manufacturing industries (excludes electric central stations, residences, etc.), in the "zone" was 53,463,513 tons, compared with 11,986,628 for the chemical industries, showing that the latter account for 22 per cent of the total fuel within the zone. But 7,500,000 tons are used in the manu-

TABLE I. SUMMARY OF POWER AND FUEL USED BY CHEMICAL AND ALLIED INDUSTRIES IN SUPERPOWER ZONE

Group	Data from 1919 Census of Manufactures									
	Establishments			Power Supply Equipment			Fuel Used			
	Total No.	Using Power No.	Ave. Hp.	Aggregate, Hp.	Prime Movers, Hp.	Purchased Power, Hp.	Coal			Coke, Short Tons
							Anthracite, Long Tons	Bituminous, Short Tons	Total Equivalent Bituminous, Short Tons	
Coke, excluding gas house coke.....	10	10	3,975	39,746	20,732	19,014	4,077	4,019,770	4,023,436	36,945
Explosives.....	23	23	850	19,522	16,049	3,473	40,157	251,416	287,489	0
Gas, illuminating and heating.....	265	202	540	108,197	103,792	4,405	1,229,102	2,399,383	3,502,208	608,629
Petroleum refining.....	21	21	3,167	66,517	65,020	1,497	1,037,653	388,913	1,322,800	222,156
All other chemicals.....	2,937	1,853	156	289,867	184,965	104,902	993,197	1,956,813	2,850,695	39,840
Total.....	3,256	2,109	248	523,849	390,558	133,291	3,304,186	9,016,295	11,986,628	907,570

facture of coke and gas, being largely converted into other forms of fuel. This leaves 4,500,000 used for power and process purposes in the other chemical industries, and this is 8 per cent of the grand total. So the place of the chemical industries in any fuel program is most important.

The total aggregate power used by all the chemical industries is 523,849 hp., which is approximately 6 per cent of the 9,069,471 hp. used by all the industries in the zone. The average size of the plants in this industry is large, 248 hp., as compared with 119 hp. for all industries.

DISTRIBUTION BY SIZE OF PLANT

Table II shows the special details for the analysis of the general chemical industry ("all other chemicals" of Table I). The same column headings appear here, considerably expanded, but all are self-explanatory. Particular attention is directed to the first two columns, as these show the special and unusual features of the

tabulation. There are four main groups, establishments using: (1) No power, (2) steam power only, (3) purchased electrical power only, (4) all other power. Each of these main groups (except "no power") is subdivided by plant size into three groups, 200 hp. and 500 hp. being the dividing lines. These groups and sub-groups are carried through all the power and fuel items. Thus there is given for each size plant and character of power supply the total power and the fuel associated with its use. The greater fuel economy of the plants purchasing power is evident, but on account of the varied nature of the processes involved conclusions are somewhat limited. However, the large use of live steam in chemical plants with independent development of power would appear to confirm the great economy of purchased power shown.

The Superpower Report will show detail tables for over fifty industries, and the system proposed will provide a convenient reliable source of power for the proper electrification of all industries.

TABLE II. POWER AND FUEL USED BY GENERAL CHEMICAL INDUSTRY

Grouped by character of power supply Data from 1919 Census of Manufactures																	
Character of Power Supply	Plant Size Hp.	Power Supply Equipment															
		Prime Movers										Energy					
		Establishments		Aggregate Hp.	Total Hp.	Steam Engines		Steam Turbines		Internal Combustion Engines		Water Wheels		Operated Total Hp.	by Electric No.	Purchased Motors Hp.	Energy Other Hp.
		No.	Average Hp.			No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.				
No power		1,084															
Steam Power Only																	
1-200.....	344	63	21,714	21,714	497	21,620	7	94									
201-500.....	69	328	22,756	22,756	198	20,656	11	2,100									
501 and above.....	53	1,480	78,476	78,476	379	49,196	81	29,280									
Sub-total.....	466	262	122,946	122,946	1,074	91,472	99	31,474									
Purchased Electric Power Only																	
1-200.....	943	22	20,788										20,788	3,459	20,788		
201-500.....	41	312	12,805										12,805	1,083	12,805		
501 and above.....	19	1,180	22,488										22,488	1,172	22,488		
Sub-total.....	1,003	56	56,081										56,081	5,714	56,081		
All Other Power																	
1-200.....	281	52	14,674	9,194	187	6,225	7	346	134	2,237	16	386	5,480	779	4,869	611	
201-500.....	49	321	15,733	9,698	121	8,028	2	225	26	615	8	830	6,035	580	6,035	0	
501 and above.....	54	1,490	80,433	43,127	459	30,824	21	8,697	30	2,017	13	1,589	37,306	2,455	37,306	0	
Sub-total.....	384	288	110,840	62,019	767	45,077	30	9,268	190	4,869	37	2,805	48,821	3,814	48,210	611	
Total (power).....	1,853	155	289,867	184,965	1,841	136,549	129	40,742	190	4,869	37	2,805	104,902	9,528	104,291	611	
Grand total.....	2,937		289,867	184,965	1,841	136,549	129	40,742	190	4,869	37	2,805	104,902	9,528	104,291	611	

Character of Power Supply	Plant Size, Hp.	Electric Motors			Run by Current Generated in Establishment			Fuel Used			Coke, Short Tons
		No.	Average Hp.	Total Hp.	No.	Hp.	No.	Anthracite, Long Tons	Bituminous, Short Tons	Total Equivalent Bituminous, Short Tons	
No power.....		1,084						17,747	38,978	54,953	327
Steam Power Only											
1-200.....	344	63	466	4,867	466	4,867		88,393	186,889	266,443	6,072
201-500.....	69	328	1,192	12,562	1,192	12,562		60,491	190,625	245,066	5,364
501 and above.....	53	1,480	5,309	63,872	5,309	63,872		304,617	736,776	1,010,933	10,509
Sub-total.....	466	262	6,967	81,301	6,967	81,301		453,501	1,114,290	1,522,442	21,945
Purchased Electric Power Only											
1-200.....	943	22	3,459	20,788				123,834	87,017	198,468	3,597
201-500.....	401	312	1,083	12,805				9,016	46,344	55,458	1,648
501 and above.....	19	1,180	1,172	22,488				14,180	86,066	98,828	180
Sub-total.....	1,003	56	5,714	56,081				147,030	220,427	352,754	5,425
All Other Power											
1-200.....	281	52	914	5,636	135	767		52,270	69,402	117,345	2,595
201-500.....	49	321	841	8,577	261	2,542		71,528	67,974	132,351	3,593
501 and above.....	54	1,490	3,510	49,691	1,055	12,385		250,121	445,742	670,850	5,955
Sub-total.....	384	288	5,265	63,904	1,451	15,694		374,919	583,118	920,546	12,143
Total (power).....	1,853	156	17,946	201,286	8,418	96,995		975,450	1,917,835	2,795,742	39,513
Grand total.....	2,937		17,946	201,286	8,418	96,995		993,197	1,956,813	2,850,695	39,840

Coking Mid-Continent Coals*

DURING the latter part of 1917 the attention of the Department of Commerce was directed to the Roberts coke and gas oven through the efforts made by the American Coal & By-Products Coke Co. to obtain Government support for this enterprise. This matter was referred to the Bureau of Standards for action.

The promoters of this process claimed a number of advantages for this oven which it was said were not embodied in other types. Among these were the following: (1) Ability to coke so-called non-coking coals



FIG. 1. GENERAL VIEW OF THE DOVER BYPRODUCTS CO. PLANT

and produce a satisfactory grade of metallurgical coke from high-volatile mid-continent coals; (2) larger yields of byproducts recovered than from other types of ovens; (3) more substantial construction than possible with existing types of ovens; (4) greater degree of flexibility of heat control than with existing types of ovens; and (5) increased earning power per oven over the other types of ovens.

At this investigation it appeared that the ovens were operating in a fairly satisfactory manner, and although the bureau was not able to verify these claims to any great extent in such a short period, the indications were that the oven could be developed into a commercial success. Therefore the Bureau of Standards reported to the Assistant Secretary of Commerce on Dec. 15 as follows:

"We do not hesitate to recommend favorably this type of oven for further consideration, for we feel sure that benefit to the Government and the people may be expected from the commercial development of the process."

ADVISABILITY OF STUDYING THE COKING OF MID-CONTINENT COALS

In addition to the lack of coke-oven plants, climatic conditions during the winter months of 1917-18 greatly reduced the coal supplies of the existing plants. Transportation of large quantities of coal became increasingly difficult as the severe winter weather continued and as the railroads became choked with materials moving toward the seaboard. This particularly interfered in the maintenance of the production at full capacity on the part of the coke ovens in the central section of the country, since most of the existing plants in this section were dependent for their coal supplies upon so-called Eastern coal. Likewise, with the increase of

traffic more and more coal was used by the railroads and the use of raw coal in boiler plants and in other industrial activities, and in the heating of dwellings, factories, etc., due to the extreme cold and lack of other fuels, depleted the supply of fuels for these ovens.

Accordingly the utilization of much of the undeveloped fuel resources of the country became a question of paramount importance. Attention was forcibly directed to the large quantities of mid-continent coal available, particularly in Indiana and Illinois, but which was not being used. Inasmuch as the steel production of large plants, such as those at Gary, Ind., and Joliet, Ill., was sometimes reduced to 30 per cent through lack of coke, it was evident that some relief was essential.

Since it was claimed for the Roberts oven that it was able to produce a first-class grade of metallurgical coke from these mid-continent coals, it was natural that this type of oven should be looked upon as a proper agency to aid in the forestalling of the crisis which seemed imminent, as well as to assist in the development of these hitherto unused coal resources of the country. Therefore using the bureau's report of Dec. 15, Mr. Roberts endeavored to interest the Government in aiding in the further development of his process and to construct two plants, one at East St. Louis, Ill., and the other at Chicago, Ill., which would use coal from the Illinois (mid-continent) field, thus avoiding the long railroad haul and accelerating the production of coke, toluene, etc.

TEST CONDUCTED BY THE BUREAU

Since the Dec. 15, 1917, report of the bureau was only a recommendation for further consideration, early in March, 1918, the Secretary of Commerce, acting by direct instructions from the President, ordered the bureau to conduct an operating test of the Roberts oven installation at Canal Dover and to associate with itself the Bureau of Mines and the Geological Survey in this work. Accordingly plans were immediately made for

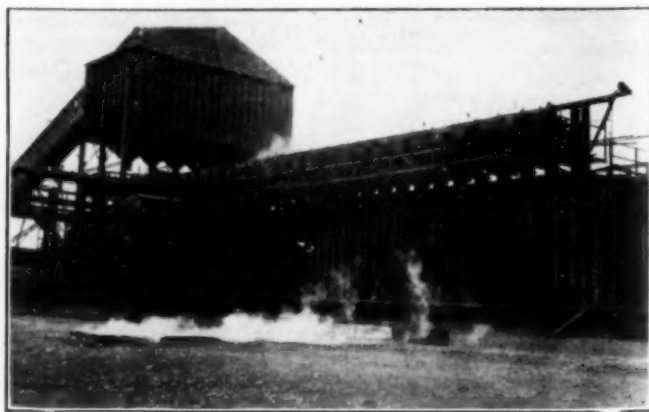


FIG. 2. PUSHER SIDE OF COKE-OVEN BATTERY

such a test, and representatives of the bureau proceeded to Dover on March 18, but found that it was not feasible to begin the test at the time specified owing to a lack of boiler capacity.

The ovens at Dover were operating at this time on Cambridge (Ohio) coal, which, although somewhat similar to the mid-continent coal's, bears a striking resemblance to the Eastern coking coals.

It was decided, however, that the test should be conducted with the same coals which would be used at East St. Louis and Chicago; therefore the bureau was

*Extracts from miscellaneous publication 46 of the Bureau of Standards entitled "War Work of the Bureau of Standards." This represents the first public announcement of results of the investigation conducted during 1918.

instructed to assist in obtaining the necessary coal for this test, together with the required boiler parts. This the bureau proceeded to do, but, hindered by numerous construction and transportation delays, it was not until April 26 that the test was officially started.

Quantitative observations of all parts of the plant operation were undertaken and were continued twenty-four hours each day, including Sundays, until May 11. During this test 4,800 tons of Illinois coal was used in the ovens, and all of the usual byproducts, including light oil, ammonia and tar, were recovered and either carefully weighed or measured. The coal used was shipped from the Royalton, Sesser and Orient mines in Franklin Co., Ill., and the Ayrshire mine, Pike Co., Ind. This work was conducted by twenty-two representatives of the Bureau of Standards and nine members of the regular staff of the Bureau of Mines; five consulting engineers were also present at the request of the Bureau of Mines to advise concerning the work.

The bureau's representatives were in charge of the test and responsible for observations of all work done about the coke oven, the byproduct department, the light-oil department and the other accessory operations. Exact records were made of the charging and discharging of the ovens, the quantities of tar, ammonia liquor, light-oil (containing benzene, toluene, etc.), and gas produced during the test period. Samples of all these materials were regularly taken, and analyses or tests of these samples made at appropriate intervals. Likewise, high-temperature measurements at various parts of the battery were carried on during the test.

The Bureau of Mines was responsible for the sampling of the coal at the mines, as it also was for the sampling and analysis the coal as it was unloaded in Dover for the test, and for the sampling, weighing and analysis of the coke produced from the test coal.

Because of mechanical difficulties the regenerators were not used during the test; therefore the ovens were not operated upon pre-heated air, but upon cold air. This precluded the making of any surplus gas, as it was necessary to use all that was obtained in heating the ovens. Difficulty was also experienced in the uniformity of the heating of the oven walls, the ends particularly being noticeably cold.

RESULTS OF TEST AT DOVER

The coke produced from three of the test coals was satisfactory as to quantity and quality, the yield being substantially the same as that obtained from other byproduct ovens. On the basis of dry coal, the yield of dry coke was 69.5 per cent, and the percentage of the sizes of dry coke to total coke were furnace size 75.1, nut 16.8 and breeze 8.1 per cent. A sufficient amount of coke was not produced by the ovens to operate the 500-ton blast furnace adjacent to the plant without the use of additional coke from other sources. Since the furnace was not able to operate at more than three-fourths capacity and since the quantity of coke had to be increased by the addition of outside coke to the extent of from 30 to 50 per cent, it was impossible to determine the real metallurgical value of the coke. However, the opinion of the superintendent of the blast furnace was that when 100 per cent of this Illinois coke was used it would make a satisfactory blast-furnace fuel with the furnace at full capacity.

The yield of toluene both as to quantity and quality was good and amounted to about 0.43 gal. per ton of dry

coal, and the yield of benzene amounted to 1.55 gal. per ton of dry coal. The yield of other byproducts per ton of dry coal were as follows: Ammonium sulphate, 26 lb.; tar, 10.7 gal., and gas about 10,000 cu.ft. However, on the basis of the quantity of these materials actually in the gas, the yields were somewhat higher than those quoted.

CONFERENCE AT PITTSBURGH

After the test at Dover was completed, a conference, which was arranged by the Bureau of Mines, was held in Pittsburgh on May 22, and the observations and results of the tests were discussed at length. Substantial agreement was reached as to what had been demonstrated by the test and what the results signified, and a report of this conference was made to the Secretary of Commerce on May 25, which was signed jointly by the directors of the Bureau of Standards and the Bureau of Mines. The report was as follows:

The Roberts oven produced a satisfactory grade of metallurgical coke from three of the four coals used. These coals have not heretofore been used to make metallurgical coke in commercial quantities. The gross yield was substantially the same as that obtained by other byproduct ovens. The coke was mixed with about an equal amount of coke from other sources, because of the limited supply of Dover coke, and was used in a blast furnace running at about three-fourths capacity. A satisfactory grade of pig iron was produced. The superintendent of the furnace is of the opinion that he could operate satisfactorily with this coke alone and at full capacity.

The quantity and quality of the gas produced were good. After removing the byproducts all the gas was used in the process of coke making. An excess of gas will be available when regenerators are in successful operation.

The quantity of byproducts in the gas was good. The amount of tar, toluene, benzene, etc., in the gas was about the same as is obtained in other ovens when high-volatile coals are used and was greater than the average yields from low-volatile coal, or the usual mixture. The amount of ammonia in the gas was very good.

The construction of the ovens is substantial. The heating system of the Dover plant leaves something to be desired in the matter of uniform heating of walls, and the regenerators for pre-heating air have not been in operative condition. Experience with the plant shows it can be improved in some particulars, and the company believes successful pre-heating of air and uniform heating can be demonstrated in a short time. It was necessary to run the test without regenerators, and as their use is essential for most efficient operation under usual conditions and in normal times, this further demonstration is believed to be necessary.

The Roberts Co. immediately proceeded to carry out the agreed program for a further demonstration, but great mechanical difficulty was experienced in putting the ovens into shape for this purpose, and it was not until the latter part of September that it was possible to complete the work.

FURTHER WORK AT DOVER

Since the War Industries Board had requested that a complete operating test be made with mid-continent coal, 1,500 tons of Orient and 1,000 tons of Ayrshire coal were secured for this test, and arrangements made whereby the coke would be stored until a sufficient amount had been accumulated, so that the blast furnace could run for several days at full capacity on 100 per cent Illinois coke.

The test began on Oct. 12, with the same methods pursued as were carried on in the May test, but before evening on Oct. 14 the representative of the Roberts Co. requested that the demonstration be stopped, since the

quality of the coke and the condition of the plant showed that it was not possible to make a successful demonstration at this time. The bureau acceded to the request, and after conference with the War Industries Board decided that until the company could demonstrate that the Roberts ovens could coke 480 tons of coal per day, the bureau would not consider another test.

CONCLUSIONS

From the investigation of these subjects by the Bureau of Standards the following facts have been demonstrated:

1. At least the majority of the coals from Franklin Co., Ill., and some from Pike Co., Ind., located in the mid-continent field, can be coked in byproduct coke ovens, and a fairly satisfactory grade of metallurgical coke can be produced. Likewise byproducts of reasonable quantity and good quality can be obtained from these coals.

2. The Roberts process at the time of these tests was still in the development stage, but credit should be given to Mr. Roberts for his work in connection with the coking of these coals. His efforts along these lines undoubtedly did much toward arousing interest among other coke-oven operators looking toward the use of mid-continent coals.

3. The bureau believes that at least some of the coal from the mid-continent field should be used in the coke-oven plants in the central section of the country. Even though the coke, on the whole, proved not to be uniformly as satisfactory as that from the so-called coking coals, the advantage due to the elimination from the coke-oven plants in the Eastern section will go far in overcoming any lack of quality of the coke. There can be no doubt that where domestic coke is wanted these coals can fulfill all requirements. Such uses will materially aid in the proper development of the fuel resources of the country.

Turret Furnace for Heat-Treating

A TURRET furnace with rotating hearth, to be used for the heat-treatment of iron and steel, has recently been installed at the plant of the Nash Motors Co., Kenosha, Wis., by the George J. Hagan Co., of Pittsburgh. Fig. 1 shows a view of the interior of the hearth. It may be noted that the stationary walls and arch are formed of specially shaped refractories, the clearance space between moving and stationary parts being closed underneath by means of a continuous sand seal. Fig. 2 shows an exterior view of the furnace, incased in sheet iron, properly reinforced. The rotating hearth itself is laid on a steel structure rotating on a series of twenty roller bearings. Six different speeds of rotation are available, from one complete rotation in thirty minutes to one in twenty-five minutes. Charging and discharging is done through adjacent doors, operated with compressed air. As shown in Fig. 1, a baffle wall extends across the heating chamber between the two doors to prevent the heated metal being chilled when charging cold material.

The first two-thirds of the furnace is maintained at a somewhat higher temperature than the remaining portion, this latter portion being a finishing or "soaking" zone.

All heating elements are separately connected to a General Electric control board, the temperature being

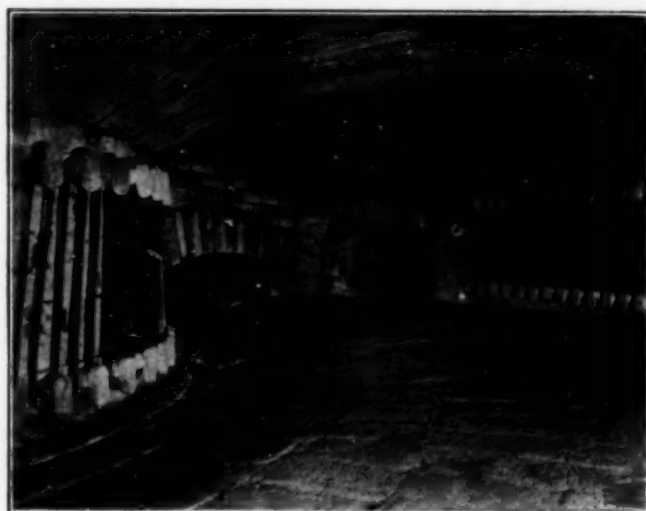


FIG. 1. INTERIOR OF THE HEARTH

automatically controlled by a two-point Leeds & Northrup potentiometer.

At night the current is switched off and the furnace loaded with iron or steel castings for annealing. In the morning the temperature will be about 1,000 deg. F., 40 minutes being required to reheat the furnace back to the working temperature—in the neighborhood of 1,525 deg. F. The furnace itself is 19 ft. outside diameter by 7 ft. high, while the diameter of rotating hearth is 15 ft., height 2 ft., and width 5 ft. It treats about 3,000 lb. per hour.

Some of the advantages claimed for this type of furnace are, first, a uniform rate of heat absorption, eliminating any distortion of long parts; second, an assurance that no metal will become overheated; third, practical elimination of scale, resulting in very much decreased time and acid consumption in pickling; fourth, the labor involved has been cut in half, from six to three men. The most important factor, however, is that the man in charge of the equipment may be supplied with a heat-treating ticket on which is shown the kind and number of pieces to be treated, the drawing temperature and speed of rotation of furnace hearth, and it is then an assured fact that these particular pieces will receive the particular treatment intended.

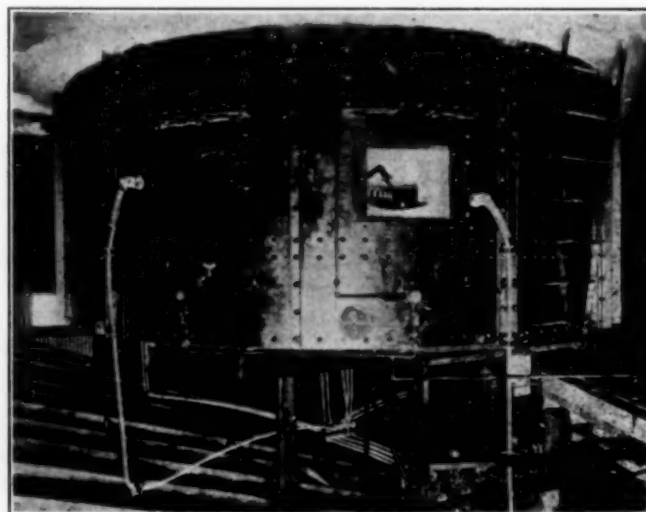
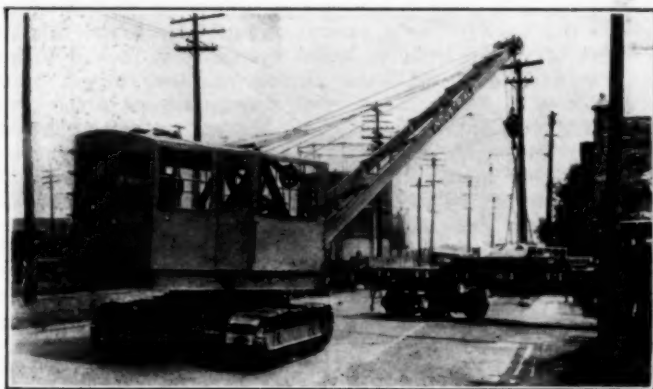


FIG. 2. EXTERIOR VIEW OF THE FURNACE

General Purpose Crawling Tractor Crane

THE Type BC "Industrial" crawling tractor crane, illustrated in the accompanying photograph, manufactured by the Industrial Works, Bay City, Mich., has been developed to meet the need for a full-revolving tractor crane which can be operated independently of rails. The crane is built in two types—the Type BC, with a capacity of 20,000 lb. at 12 ft. radius, is equipped with continuous crawling tractor belts; the Type BT, with a capacity of 18,000 lb. at 10 ft. radius, is equipped with four broad-gage tractor wheels.

The maximum utilization of yard storage space is realized with the use of these cranes, because their field of usefulness is not limited by railroad tracks, as in the case with the railroad crane. Having exceptionally



GENERAL PURPOSE CRAWLING TRACTOR CRANE

large capacities in ordinary lifting, they prove a valuable adjunct in those many erection jobs which are inaccessible to the railroad crane.

They can be equipped to handle a hook and block, grab bucket, drag scraper bucket, wood grapple, electric lifting magnet, shovel dipper and pile driver leads with drop hammer.

Operation is by means of an internal-combustion engine which has the advantages of being always ready for immediate use. When not in operation no fuel is consumed and it is not necessary, as often with a steam-operated machine, to have a licensed engineer as operator. Up to the capacity of the motor any combination of clewing, hoisting the load and varying the radius may be made.

The crane is equipped with a 30-ft. beam made up of two channels strongly latticed with angles and tie plates.

The steering of the crawling tractor crane while propelling is accurately controlled by the operator from his position in the revolving upper-works, by manipulation of the friction clutches and brakes controlling the motion of each tractor belt. By means of these clutches and brakes either tractor belt can be readily and instantly disconnected from the motor while the other belt continues traveling at the normal rate of speed.

The disconnected tractor belt can be held stationary by applying the brake, can be allowed to coast with the brake and clutch both disengaged, or the clutch can be allowed to slip, thus allowing operator to turn as sharp or as wide a corner as he may select. All the clutch-, brake- and lever-mechanism for steering is located in the revolving upper-works, where it is simpler and much more accessible than when a portion or all of this mechanism is located on the car-body.

Book Reviews

INDIA RUBBER GOODS MANUFACTURE. By "Factory Manager." London: Maclaren & Sons, Shoe Lane. Price \$7.75.

It is a pleasure to review the work of one who has honestly tried to set down his own experience and to describe in detail his best methods. This book is evidently the work of one who has actually been a factory manager. He knows how things are made. He is to be commended for producing such a detailed description of rubber goods manufacturing as he knew it. The work is quite voluminous, 484 pages, and discusses in more or less detail almost every phase of rubber goods manufacture.

However, it will be at once apparent to the American reader that it does not properly describe American practice. The reviewer is not familiar with English methods and cannot say as to how well they are covered. In so far as our methods are concerned the book covers those in vogue about five years ago. Except for druggists' sundries and mechanical goods the formulas given have been out of use for many years. Organic accelerators were unknown in the author's time. Black was used for coloring purposes only. Today most formulas of merit contain one or the other or both.

But do not let this worry the reader. The book contains many useful and valuable pointers in regard to the factory handling of various products. In a few lines the old methods are still followed.

Perhaps the only criticism in addition to being somewhat antiquated is that items of small importance, such as cash mats, are discussed to almost the same length as pneumatic tires, a subject of infinitely greater value.

From the mechanical goods and druggists' sundries standpoint the work is well done. Sizes and specifications are of course not applicable to American practice, but they give the reader an approximate idea of construction.

ANDREW H. KING.

Synopsis of Recent Chemical & Metallurgical Literature

Properties of Molybdenum Steels.—A paper giving tests on heat-treated Mo and Cr:Mo steels was presented by H. J. French before the recent meeting of the American Society for Steel Treating. The important features determined may be summarized as follows:

1. Steel containing 0.20 per cent carbon and 1 per cent molybdenum.

1. For each maximum temperature of heating there is a critical rate of cooling which will lower A_r . The higher the initial temperature the slower is the rate of cooling required to produce the lowered transformation, but by whatever combination this is produced the position of the "low point" is fixed within a narrow temperature range: about 525 deg. C. (975 deg. F.). Its suppression can readily be brought about, however, by increasing the rate of cooling.

2. A high temperature transformation is observed slightly above and almost merging with A_r when the steel is cooled from temperatures at or above 960 deg. C. (1,760 deg. F.) at a rate of temperature change approximating 0.15 deg. C. (0.27 deg. F.) per second, but is not observed when cooling at a much faster rate.

3. A_r is fixed at about 760 deg. C. (1,400 deg. F.) independent of the maximum temperature of heating or rate at which the steel is cooled.

4. The most suitable temperature from which to harden the steel is in the neighborhood of 910 deg. C. (1,670 deg. F.). Free ferrite is found after quenching from 830 deg. C. (1,525 deg. F.), but the observed changes in mechani-

cal properties with rise in quenching temperature within this range cannot be explained by known changes in carbon or iron, by differences in the rate at which the steel passes through the critical ranges resulting from changes in initial temperature of cooling, by unsatisfactory hardening or by the lowered A_1 transformation (except as related to a molybdenum change), for they are opposite to the changes found in plain carbon steel under similar conditions of treatment.

5. For the production of definite tensile strength, water-quenching is to be preferred on account of the higher proportional limit, ductility and impact values obtained, and conversely better tensile properties are obtained for a given impact resistance.

6. Raising the quenching temperature from 910 deg. C. (1,670 deg. F.) to 980 deg. C. (1,795 deg. F.) does not materially alter the mechanical properties of the steel when subsequently tempered at a relatively high temperature 540 deg. C. (1,000 deg. F.).

II. Steel containing 0.27 per cent carbon, 0.9 per cent chromium and 0.5 per cent molybdenum.

7. The A_1 transformation is first split and lowered when cooling from 960 to 1,000 deg. C. (1,760 to 1,830 deg. F.) at about 0.15 deg. C. (0.27 deg. F.) per second, the "low" point being observed at about 480 deg. C. (895 deg. F.). In water-quenching from the highest temperature, a lower hardness is obtained than when similarly cooling from 960 deg. C. (1,760 deg. F.). In this respect the chromium:molybdenum steel behaves similarly to steel containing 0.20 per cent carbon and 1 per cent molybdenum except that the observed changes are produced from higher temperatures.

8. In normalizing the chromium:molybdenum steel, a low limit of proportionality and impact resistance is obtained when using temperatures between about 780 to 845 deg. C. (1,450 to 1,550 deg. F.).

9. The fact that no material changes in tensile or impact properties are produced by oil-quenching the chromium:molybdenum steel from a wide range of temperatures when subsequently tempered at 540 deg. C. (1,000 deg. F.) has been confirmed. To produce high impact values in the hardened steel, a tempering temperature in the neighborhood of 650 deg. C. (1,200 deg. F.) is required.

Effects of Surface Scratches.—An important paper on this subject was read before the recent Engineering Conference of the British Institution of Civil Engineers by Prof. E. G. Coker. He noted that the importance of having a smooth surface in metals exposed to a high stress has been recognized by many engineers who impart a high degree of finish to their work, especially in cases where an intense stress varies cyclically, as in the moving parts of high-speed machinery. The increased strength and extension due to a high degree of polish in a tension test-piece has also been frequently noted, and the elimination of scratches appears to be of importance in many other cases.

It seems likely that the scratches produced by ordinary machining operations may be considered as minute notches in the surface, probably with plane or curved sides inclined at a considerable angle and rounded off at the bottom of the notch by curves with radii much greater than the average size of the unit of crystalline structure of the metal. If a scratch is made in the edge of a plate in tension, it may be shown¹ that a mean tension of one-third the yield point or even less will cause a permanent set at the scratch, while, if the load is alternating, these indentations gradually penetrate farther and farther into the material, apparently along planes inclined at 45 deg. to the line of pull in ductile bodies—that is, along the planes of maximum shear stress.

In a group of scratches sufficiently close to affect one another, the combined result is, naturally, still more noticeable, and the failure of a material under a comparatively moderate mean stress, due to surface scratches, is not difficult to understand, especially if the loading is of an alternating kind.

The form of the scratch is all-important. A scratch pro-

ducing a semi-circular groove in the material may raise the stress to about double the average stress, while a groove with straight sides at 45 deg. and a radius at the apex of one-eighth of the depth gives an increase of rather less than five times the mean stress. Increased sharpness of curvature at the bottom of the notch produces still greater local stress, and this latter may easily cause a fine crack to develop and produce failure owing to its rapid extension.

Surface of Liquid Steel.—Cosmo Johns read a short paper before the British Association, Sept. 13, 1921, on why liquid steel at 1,600 deg. C. was able to preserve its surface unoxidized. The author pointed out, as reported in *Iron and Coal Trades Review*, that this was especially noticeable in steel as it flowed from the furnace into the ladle. He had previously suggested that the obvious explanation was that the vapor of the steel formed a protecting medium, but there was some objection to this theory. He had noticed that sparks were given off the metal when it was being poured, and also that floating above the stream was a greenish fume. He found this to consist of minute spheres which on analysis proved to be all magnetic oxide of iron. It was not easy to get pure samples of this fume because of the impurities in the surrounding atmosphere, but he did succeed in getting some samples and made observations on a complex alloy containing other metals than iron. He found, as he had expected, that if the analysis of this oxidized material was calculated to the metallic elements from which it was formed, the result differed in no marked degree from the original steel as regards chemical composition.

Recent Chemical & Metallurgical Patents

British Patents

For complete specifications of any British patent apply to the Superintendent, British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Cellulose Ethers.—Alkyl ethers of cellulose, more particularly ethyl and methyl ethers, are prepared by treating cellulose or its near conversion products not soluble in alkali, such as mercerized cellulose, with a suitable alkylating agent in the presence of alkali, under such conditions that (1) the quantity of water present or added, disregarding water formed during the process, is at no stage of the etherification greater than about four times the weight of cellulose and preferably not in greater amount than about one-half and one-and-a-half times this weight, or it may even be as low as the natural humidity content of the cellulose, and (2) the total quantity of alkali is at least equal to and preferably exceeds by 3-19 or more times the weight of water present or added. The ethers so obtained are characterized by their insolubility in hot or cold water and by the fact that they are not precipitated from alcoholic solution by alcoholic solutions of alkali; and the same properties hold in the case of the intermediately formed partly etherified ethers. The requisite quantities of water and alkali are added prior to the alkylating process, or partly or entirely during the process, either continuously or by stages; and the alkylating agent is introduced all at once or continuously or in stages, but preferably in such a manner that an excess of alkali is always present. For making highly ethylated ethers it is necessary to employ relatively to one molecular equivalent of cellulose, $C_6H_{10}O_5$, 8-20 molecules of alkali and 5.9 molecules of diethyl sulphate. The temperature of the reaction varies according to the alkylating agent selected, etc.; in the case of diethyl sulphate, the temperature may be between room temperature or even lower, and 88 deg. C., but preferably below 55 deg. C.; with dimethyl sulphate, it is preferred to keep the temperature at 0 deg. C., or even lower; and in the case of alkyl halides the temperature is preferably raised to some point between 50 and 80 deg. C.

¹E. G. Coker, "Photo-elastic Measurements of the Stress Distribution in Tension Members Used in the Testing of Materials." *Min. Proc. Inst., C. E.*, 1921.

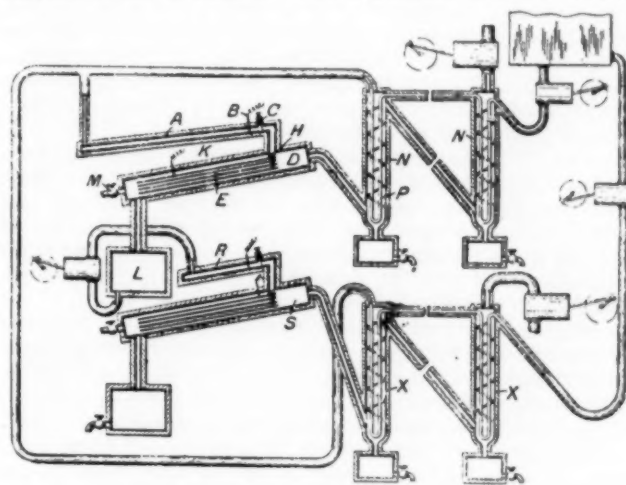
The reaction is accelerated by the addition of contact substances such as powdered copper or copper salts or hydroxides. It is advantageous to carry out in the reaction in the presence of liquid diluents such as benzene, which do not themselves suffer etherification, since such addition facilitates mixing and renders the reaction more uniform. In examples, one molecular equivalent of cellulose, etc., is kneaded with four molecules of caustic soda and an equal weight of water, and 1-2 molecules of diethyl sulphate are added while maintaining the temperature at 40-55 deg. C. or between ordinary temperature and 30 deg. C., with subsequent additions of 4-6 molecules of powdered caustic soda and 2-3 molecules of diethyl sulphate, and 4-6 molecules of caustic soda and 2-2½ molecules of diethyl sulphate, the products being eventually separated and washed with water; one molecular equivalent of cellulose, etc., is impregnated with an equal weight of water, kneaded with four molecules of caustic soda and 1½ molecules of diethyl sulphate added while keeping the mixture at a temperature of 40 deg. C., with subsequent additions at intervals of caustic soda and diethyl sulphate until a total of 12-18 molecules of the former and 6-8½ molecules of the latter have been added; one molecular equivalent of cellulose, etc., is impregnated with 20 per cent caustic soda and after standing is squeezed or centrifuged until the mass contains an amount of water equal to the weight of cellulose, whereupon 4½ molecules of caustic soda are added and the process continued as in the first example above; one molecular equivalent of cellulose, etc., is treated with a 50 per cent solution of 4 molecules of caustic soda, the mass thoroughly kneaded, then two molecules of dimethyl sulphate are added while maintaining the temperature at 5 to 10 deg. C., and subsequently 4-6 molecules of caustic soda and 2-3 molecules of dimethyl sulphate, and 4-8 molecules of caustic soda and 2-3½ molecules of dimethyl sulphate; and in these examples the diethyl and dimethyl sulphate may be introduced as a solution in an equal weight of benzene. By employing mixtures of different alkylating agents, "mixed" ethers may be obtained; or the cellulose may be partly etherified while employing one or more alkylating agents and then further etherified with another or others. The ethers obtained according to the above process may be employed in the manufacture of films, artificial filaments, celluloid-like masses, electric insulating materials, varnishes, dopes and coating materials. Aralkyl ethers, such as benzyl cellulose, and mixed ethers can be prepared in a similar manner. (Br. Pats. 164,374, 164,375 and 164,377. H. Dreyfus, London. July 27, 1921.)

Bornyl Esters; Borneol; Isoborneol.—Esters are prepared from turpentine and an acid, such as formic, acetic, butyric, sebacic, benzoic, salicylic, but preferably oxalic acid with the aid of a liquid "catalyst" such as methylene chloride, chloroform, carbon tetra-chloride, ethylene chloride or bromide, tetra-chlorethane or trichlorethylene; benzene and acetone are less effective. The "catalyst," turpentine, and anhydrous oxalic acid may be heated together at 115 to 125 deg. C., sufficient of the "catalyst" being used to bring the boiling point of the mixture to the required temperature. The product is mainly the neutral bornyl oxalate, from which excess of turpentine and the "catalyst" may be distilled first in vacuum and then in steam, and may be re-used. The ester is saponified by soda, and the solid alcohol oxidized to camphor by known methods. With sebacic acid, an acid ester is obtained. (Br. Pat. 164,357; not yet accepted. L. Darrasse and E. Darrasse of Paris and L. Dupont of Vincennes. July 27, 1921.)

Celluloid From Cellulose Ethers.—In the manufacture of solutions, films, artificial filaments, celluloid-like masses, electric insulating materials, varnishes, coating and other compositions, preparations and articles having as a basis the cellulose ethers described in specifications 164,374, 164,375 and 164,377, the alkylated sulphonamide derivatives or preparations described in specifications 132,283 133,353 and 154,334 are employed as high boiling point solvents or plastic-inducing agents; the cellulose ethers, esters used alone or mixed with other ethers, esters or derivatives of cellulose, and in conjunction with the sulphonamides there may be used other high boiling-point solvents such as triacetin, and lower boiling-point solvents or liquids, and other additions such as triphenyl or tricresyl phosphate, castor oil,

aliphatic derivatives of urea, coloring matters, filling materials, etc. In an example, a celluloid is prepared from an ether obtained according to the examples given in specification 164,374, using, as a high boiling-point solvent, benzene mono-methyl sulphonamide, toluene-o-monoethyl sulphonamide or mixtures of isomeric xylene mono-methyl or mono-ethyl sulphonamides, in conjunction with triphenyl or tricresyl phosphate, and alcohol or alcohol-benzene; the hardness of the product is adjusted by increasing and decreasing simultaneously the proportions of sulphonamide derivative and triphenyl or tricresyl phosphate. In another example describing a solution for use in the manufacture of films or as a varnish, the ether is dissolved in alcohol or alcohol-benzene, and the sulphonamide derivative added with or without triphenyl or tricresyl phosphate. (Br. Pat. 164,384, 164,385 and 164,386. H. Dreyfus, London. July 27, 1921.)

Forming Asphalt From Petroleum Residue.—The residue from the distillation of petroleum oils, distillates and tars is treated to form asphalt by heating it under pressure to 250-300 deg. C. and distributing it over inclined plates in a chamber heated to the same temperature, though which a current of air is passed. The apparatus is combined with



apparatus for distilling oils, etc., described in specification 163,363. (See CHEM. & MET. ENG., p. 669, 1921.) The oil, heated by passage through the tubes P in condensers N and through a tube A heated by an electric coil is distributed by funnels H onto inclined plates E in a chamber D also heated by a surrounding electric coil. The vapors evolved are withdrawn by a pump and condensed fractionally in a series of condensers N. The unevaporated residue passes to a vessel L and is pumped through a second heating tube R, and distributed over inclined plates in a heated chamber S to which air is admitted through a cock U. Vapors evolved in the chamber S are withdrawn through a series of condensers X cooled by passage of crude oil through pipes contained within them. In a modified apparatus, the heating tubes and evaporations are heated by gas or oil fuel burners, the residue from the first evaporator is passed through the cooling coils of the condensers connected to the asphalt chamber, and is passed through an intermediate heater and evaporator before being treated to form asphalt. (Br. Pat. 163,656. V. C. Illing and J. Kelly, both of London; July 13, 1921.)

Purifying Illuminating Gas.—A process for the purification of illuminating gas consists in first treating the gas in a washer with a liquid consisting of a solution of a ferrous salt and milk of lime and then with the solid residue filtered from the above-mentioned liquid after this residue has been exposed to the air and mixed with sawdust. In the first stage, the cyanogen in the gas forms prussiate of lime and remains in solution and part of the sulphuretted hydrogen forms iron sulphide which remains in the residue. In the second stage the residue when exposed to air forms a purifying material of ferric hydrate mixed with sulphur, sulphate of lime, carbonate of lime, etc., which removes the remainder of the sulphuretted hydrogen. (Br. Pat. 164,310; not yet accepted. Société du Gaz de Paris. July, 27, 1921.)

Current Events

in the Chemical and Metallurgical Industries

American Engineering Council

Unanimous election of M. E. Cooley, dean of the College of Engineering and Architecture of the University of Michigan, to be president of the American Engineering Council of the Federated American Engineering Societies was announced at a meeting of the executive board in Washington, Sept. 30. Dean Cooley's connection with the University of Michigan dates back to 1881; his influence on engineering practice in the United States therefore needs no emphasis. Among his many honors, the most recent was presidency of the American Society of Mechanical Engineers.

Resolutions were adopted expressing the opinion that the Lampert bill to remedy conditions in the Patent Office "provides the least increases in force and salaries which can possibly stop retrogression . . . and enable it to recover an efficient condition." Opposition was also voiced to the Stanley bill, a bill which requires that alien-owned patents must be worked in this country within two years else outsiders may obtain licenses to develop them.

In view of the unemployment among engineers, the need of a well-financed unified employment service and the inadequate contributions which the constituent societies can make toward such activities, a committee was appointed to work out a plan whereby interested organizations may co-operate in forming a "paid employment service, but in reduced fees to members of supporting organizations."

Government contracts were discussed at length, and the board made the following recommendations: "That Government work be normally carried out through unit price, or lump sum contracts, or by the purchase and hire method. Where none of the above methods are applicable to conditions, that the cost-plus method be used, in which the contractor is refunded the actual cost of the work, plus an accorded compensation which increases if the work is done below the estimated cost of the work and decreases if the work costs more than estimated, but never sinks below zero"; that an effort be made to standardize Government contracts and that partial payments be promptly made to contractors without the use of intermediaries.

In view of the business depression, it was decided not to hold an engineering assembly next January. The committee in charge of the arrangements was converted into a program and entertainment committee for the annual meeting of the council to be held in Washington in January.

The applications for membership of the Vermont Engineers Society and the Associated Engineers of Spokane were approved.

To Make Steel From British Columbia Magnetite

The Vancouver Magnetite Steel Smelting Co. has made arrangements to erect a 50-ton electric smelter at Nanaimo, on Vancouver Island, B. C., provided satisfactory arrangements can be made with the city. The city has appointed a committee to confer with Messrs. Fraser and Lewis of the company, and it is probable that a satisfactory understanding will be reached.

The company claims to have spent \$67,000 in experimental work and to have produced a high-grade steel from British Columbia magnetite. It will develop its own water power from the Nanaimo River; it claims to have \$5,000,000 of British capital behind it. The company is not purposing to use any new process, but those that have already been tried and proved in Norway and Sweden.

Increased Production of Alsatian Potash

It is reported that the Alsatian potash mines will double their output during October and that they will probably produced during 1922 10,000 tons of potassium chloride per month. Large quantities will be available for export.

Unemployment Decreases in Chemical Industry

An increase in the number of men employed in the chemical industry was shown during September, according to the figures of the U. S. Employment Service. The increase on Sept. 30 as compared with Aug. 31 was 2.6 per cent.

Chemical Tonnage on Railroads

Chemicals and explosives contributed 1,260,098 tons to the freight tonnage on class 1 railroads during the second quarter of 1921. Fertilizers to the extent of 1,800,407 tons were handled during the second quarter. The amount of vegetable oils moved was 262,808 tons. Pulpwood to the extent of 1,196,094 tons was shipped during that quarter. The figures are those of the Interstate Commerce Commission.

Metric System Bill Hearing

Hearings on Senator Ladd's metric system bill were to have begun Oct. 11. Among the witnesses who probably will appear in favor of the bill are Harvey W. Wiley, former chief of the Bureau of Chemistry; S. L. Hilton, president, American Pharmaceutical Association; Dr. Charles L. Parsons, secretary, American Chemical Society; William J. Schieffelin, a drug manufacturer of New York; Theodore H. Miller, works manager of the De Laval Separator Co., and Howard Richards, Jr., secretary, American Metric Association, of New York.

The executive board of American Engineering Council, which met in Washington Sept. 3, decided to take no part in the metric system controversy.

Iron and Steel Electrical Engineers Chicago Meeting

During the week of Sept. 19 the Association of Iron and Steel Electrical Engineers held its fifteenth annual convention at the Hotel La Salle, Chicago. Educational features included exhibits of representative manufacturers of electrical steel mill apparatus and inspection trips to plants in Chicago.

The fuel economy program was conducted under the auspices of the new section on Combustion Engineering. Fuel papers presented included "Fuel Requirements in Steel Mills," by S. E. Leahy; "Control of Boiler Operation," by W. S. Flannigan; "General Use of Oxygen in the Steel Mill Industry," by E. A. W. Jefferies, and "Waste Heat Utilization for Steam Generation," by G. R. McDermott.

The paper on "Fuel Requirements in Steel Mills" dealt with the various forms of fuels and touched upon the economic considerations such as transportation, storage and distribution, outlining some of the peculiar requirements and reasons why it is desirable to use various fuels in various steel mill operations. In the discussion on this paper attention was called to the desirability of taking occasional heat balances to assist in planning improvements and in properly proportioning the blast-furnace gases between the different services. Coke breeze is being used in increasing amounts in smaller plants, with an efficiency of 60 to 65 per cent. In especially designed waste heat boiler 27 tubes wide and 24 tubes high, efficiencies as high as 80 per cent have been secured as compared with the usual 70 per cent. Coke-oven gas has been burned with good results in open-hearth furnaces, but greater capacities are obtainable with tar.

In Mr. Jefferies' paper, on the "Influence of Cheap Oxygen on Economy of Fuel and Time," it was shown that the problem of cheap oxygen has been solved. When made at the rate of 4,000 cu.ft. per minute it can be produced for 8c.

per 1,000 cu.ft., as compared to the present rate of \$10 to \$15 per 1,000 cu.ft. when bought in the usual storage cylinder. In general, the process consists of liquefying the air by compressing and subsequent expansion to distill off the nitrogen in the liquid air columns.

In the steel industry and in other fields, the availability of cheap oxygen constitutes prospects of the greatest conceivable importance. The author intimated that fuel gas of 400 B.t.u. could be produced for 8c. per 1,000 cu.ft. The gas contained about 60 per cent carbon monoxide, which has a higher flame temperature than any other gas in general use, making it more desirable than coke-oven or natural gas.

Uses of oxygen in the open-hearth furnace, in the blast furnace and many miscellaneous places such as cutting metal welding and stimulating combustion were briefly touched upon by the author. The discussion centered upon combustion temperatures that would prevail when enriching in oxygen and the impossibility of present refractories withstanding such temperatures. If used in a power plant, it would necessitate the redesign of boilers and furnaces.

G. R. McDermott reviewed what has been accomplished in the utilization of waste gases for steam generation and pointed out sources of waste heat which may be available, referring in particular to open-hearth furnaces, soaking dips, reheating furnaces, malleable melting furnaces, forge furnaces and gas engines using blast-furnace gas.

To utilize the source of waste heat from blast-furnace gas the author has designed a high-mass velocity, fire-tube single-pass waste heat boiler to take the exhaust at a temperature of 850 deg. F. from 3,300-kw. gas-engine units. Based on an average load of 3,000 kw., it was estimated that the boiler would generate 2.6 lb. net of steam per kw.-hr. at the switchboard. Heat and absorption phenomena in direct-fired and waste-heat boilers were compared and the relative merits of water-tube and fire-tube boilers as absorbers of waste heat, the author favoring the last-mentioned type.

The officers elected for the coming year were: President, W. S. Hall, electrical engineer, the Illinois Steel Co.; first vice-president, R. B. Gerhardt, electrical engineer, the Bethlehem Steel Co.; second vice-president, L. F. Gailbraith, electrical engineer, the West Penn Steel Co.; treasurer, James Parrington, electrical superintendent, LaBelle Iron Works; secretary, J. F. Kelly, Pittsburgh, Pa.

The headquarters of the association are 1007 Empire Building, Pittsburgh, Pa.

Stainless Iron

According to the *Ironmonger* (London), a new stainless steel has been put on the market by three British firms in bars and sheets. It is derived from the well-known stainless steel, and differs from the latter principally in that it contains carbon less than 0.10 per cent. Carbon-free chromium or ferrochromium is thus required, either of which are expensive substances. Therefore the new metal is more expensive than brass, but it is easier to keep clean. This new low carbon chromium:iron alloy is distinctly softer than stainless steel and is thus suited to various manipulations: a wide range of uses in forging, pressing and stamping. Already success is reported in producing automobile wheel disks, hoods, bodies and other products subject to corrosion or tarnishing, thus eliminating painting and varnishing.

Reduced Duty for Earthenware Embossed in Mold

The Board of United States General Appraisers, New York, has handed down a ruling sustaining a number of protests against the assessment of duty at 40 per cent on imported earthenware embossed in the mold. The assessment at such rate under the provisions of paragraph 79 of the act of 1913 covers "decorated earthenware." The importers' claim, sustained by the board, covers an assessment of 35 per cent under the same paragraph, for "earthenware, not decorated."

Lecture Course in Burning of Clay Products

A course of twenty-five lectures on the burning of clay wares, firing of boilers in the pottery, firing efficiency and other phases of fuel combustion is being arranged at the School of Industrial Arts, Trenton, N. J.

Central Steel Co. Merger

Steel mill properties with combined assets in excess of \$20,000,000 have been brought together in the merger just completed of the Central Steel Co., the National Pressed Steel Co. and the Massillon Rolling Mill Co., all of Massillon, Ohio.

The new corporation, it is announced, takes the name of the Central Steel Co. and the following officers have been elected: Chairman of the board of directors and president, R. E. Bebb; first vice-president, F. J. Griffiths; second vice-president, C. C. Chase; third vice-president, H. M. Naugle; secretary and treasurer, C. E. Stuart.

The merger of the three companies brings the Central Steel Co. into prominent position among the largest steel producing corporations of the country, with complete modern equipment and facilities for producing all kinds of commercial alloy steels, hot- and cold-rolled sheets, hot-rolled strip steel and light structural steel sections in a combined annual output of 450,000 to 475,000 tons of finished material.

The Central Steel Co. brought to the merger ten open-hearth furnaces of 65 to 75 tons capacity, 34-in. blooming mill, 24-in., 18-in. and 12-in. finishing mills, 24-in. sheet bar mill, cold-drawing and heat-treating departments and a record of being the largest producer of strictly alloy steels in United States. The Central company annual tonnage runs from 300,000 to 325,000 tons.

The National Pressed Steel Co., which will function in the future as a division of the Central Steel Co., is a producer of hot-rolled strips and plates and finished structural steel joist sections with a present capacity of approximately 100,000 tons annually. Equipment is all modern and includes slab furnaces, annealing furnaces, complete pickling and finishing facilities, electro-driven hot-rolling mill with gage range from No. 15 to 1 in., widths up to 24 in. and lengths up to 130 ft., cold-forming steel lumber section mills, electric welders and other equipment for furnishing steel lumber finished and painted ready for use.

The Massillon Rolling Mill Co., which also will be operated as a division of the Central Steel Co., brings to the merger twelve hot sheet mills, sixteen cold sheet mills, eighteen annealing furnaces and complete equipment and facilities for turning out a complete line of sheet steel.

Declining Importance of Chilean Nitrate

Those charged with the operation of the Panama Canal see in the large decrease in nitrate shipments a factor having an important bearing on canal traffic. "The interests of the Panama Canal are affected," they state, "not only because nitrate made up one-third of the total northbound cargo in 1920, but because the smaller number of shipments has had an adverse effect on bulk cargo moving in the opposite direction. Vessels which carry coal cargoes south usually return with nitrates, so the decay of one involves a corresponding decline in the other."

The canal authorities attach importance to the following analysis of the nitrate situation by A. Bertrand, the delegate in Europe of the Association of Nitrate Producers:

"Before 1908, nitrate had but one rival, sulphate of ammonia, with a development very inferior to nitrate. From 1909 to 1913 cyanide and nitrate of calcium began to make their appearance, while at the same time the production of sulphate of ammonia increased much more than that of nitrate. In 1913, in its turn, synthetic ammonia made its appearance, though in a small proportion. In that year nitrate was still dominant.

"In 1917 the development of nitrate reached its maximum capacity. Synthetic ammonia was produced to a maximum degree in Germany in 1918. Sulphate of ammonia, extracted from coal, seems to have reached its full development in Germany and the United Kingdom and especially in the United States, while it continues to increase in other countries, notably Australia and Japan. At the present moment, the production of chloride of ammonia and other new salts is being encouraged for the purpose of fertilization.

"To sum up, nitrate, which represented 56 per cent of the world's total fertilizer production in 1913 to 1917, has fallen today to less than 35 per cent, according to the most favorable calculations, and it seems threatened with a descent to still lower depths in the current year."

Rubber Manufacturers' Association Organized

Rubber manufacturers at Trenton, N. J., have perfected plans for the organization of a new association, to be known as the Rubber Manufacturers' Association of New Jersey. The new organization is designed for mutual benefit of members, exchange of plans and ideas and for the general betterment of trade conditions. The trustees elected for the ensuing year include John S. Broughton, the United Globe & Rubber Co., president; Charles E. Stokes, an official of the Home Rubber Co., vice-president; A. Boyd Cornell, of the Hamilton Rubber Co., secretary, and W. H. Sayen, Jr., connected with the Mercer Rubber Co., treasurer. Offices will be located in the Broad Street Bank Building, with V. B. Wicoff as representative.

Personal

Dr. ELMER D. BALL has been chosen by the Secretary of Agriculture to be the first director of scientific work. The office was created in the last agricultural appropriation bill so as to provide an official who would be in immediate general charge of all research work in the department. Through Dr. Ball an effort will be made to co-ordinate and correlate the scientific work of the department in a way to make it more effective in the study of national problems having a bearing on agriculture.

M. J. CAVALIER, professor of metallurgy in the University of Toulouse, France, was the guest of honor at a meeting of the New York Section, American Institute of Mining and Metallurgical Engineers, on Oct. 5. Responding to a toast, he spoke on the influence of French universities on industries, and of the great expansion of the French metallurgical and electrochemical industry since the beginning of the war. As exchange professor, Dr. Cavalier will divide his time among Columbia, Harvard, Yale, Cornell, Johns Hopkins, Massachusetts Institute of Technology and the University of Pennsylvania.

J. D. CLARKE, general counsel for the Midwest Refining Co., Denver, Col., has been elected vice-president of the company to succeed R. D. Brooks, resigned.

MORTIMER ELWYN COOLEY, dean of the College of Engineering and Architecture of the University of Michigan, has been elected president of the American Engineering Council of the Federated American Engineering Societies. Dean Cooley assumes office at once and will carry out an extensive program in the interest of the public and the profession of engineering.

A. L. HALVORSEN of Perth Amboy, N. J., is planning to spend October and November in Germany and Norway inspecting the various activities in industrial chemical research and cyanide hydrometallurgy.

MILTON R. LOURIA, who completed his chemical engineering course at Columbia University last June, has been appointed instructor in chemistry at the University of Maine for the current year.

P. L. PALMERTON has been named chief of the newly established rubber division of the Bureau of Foreign and Domestic Commerce.

LINCOLN T. WORK has been appointed instructor in chemical engineering at Columbia University for the year beginning Oct. 1. Mr. Work completed three years of graduate work in the department of chemical engineering at Columbia last June.

Prof. ALFRED H. WHITE, director of the department of chemical engineering, University of Michigan, addressed the Rotary Club at Bay City, Sept. 20, on "The Chemistry of War."

Friends of DR. HENRY M. HOWE will be sorry to know that for several weeks he has been practically confined to his bed with rheumatism.

Current Market Reports

The Chemical and Allied Industrial Markets

NEW YORK, Oct. 10, 1921.

Business in the heavy chemical market during the past week has been steadily improving and inquiries for a variety of minor commodities have been more plentiful. The general tone of the market was much stronger than during the past few weeks owing to the scarcity of spot material in resale quarters. Although buyers are still operating in a conservative manner, the volume of business has increased as the demand for finished products becomes greater. The general feeling in the trade is that a gradual revival will feature the market for the rest of the year.

The feature of the week's trading was the pronounced strength of prussiate of soda, cyanide of soda and soda ash. The market on these products closed very firm, with sellers showing very little desire to sell at the existing low prices. There has been an increased inquiry for solid caustic soda and the market is responding to increased buying orders. The demand for this material has been chiefly from domestic consumers. Soda ash is another chemical that has displayed considerable strength during the past few days. Glass factories are the foremost in the field of domestic consumers for this chemical and an increased inquiry has also been evidenced from smaller buyers. Bichromate of soda was reported a shade easier by some resale merchants in the final trading, while leading factors maintained their former price range.

CHEMICALS

Sellers of *bichromate of potash* ask 11@11½c. per lb., with several sales reported at the inside figure. The movement in this chemical has been somewhat dormant of late with the few inquiries passing calling only for small lots. Spot material does not seem to be plentiful, but competition is keeping prices irregular. Spot *carbonate of potash* has moved very quietly during the week and the market closed nominal at 4½@4¾c. per lb. for the 80-85 per cent, calcined. Imported *chlorate of potash* is offered at 6¾@7¼c. per lb., according to the quantity and seller. There has been no change noticed in the domestic goods and first hands quote their former price of 12c. per lb., f.o.b. works. Some sales have been recorded on spot *caustic potash*, 88-92 per cent, at 5½c. per lb. Offerings of this material were not heavy, but buyers were not eager to keep in line with the advance and therefore the demand eased up considerably. Shipment prices from Germany ranged from 5@5½c. per lb., with goods afloat held at 5c. Small lot sales of *bichromate of soda* were reported on the spot market at slightly lower figures. Quiet conditions for this chemical are responsible for the shading among holders of resale goods. Additional lots of standard brands were reported in the market at 7½@7¾c. per lb. A sale of 10 long tons was recorded early in the week at 7¼c. per lb. f.a.s., N. Y. The late advances in solid *caustic soda* are being well maintained on spot and the market closed in a very favorable condition. Inquiries for small lots from various consuming quarters were quite frequent during the entire week and sales have been reported at \$4.05@\$4.15 per 100 lb., according to seller and quantity. At the works 3¼c. per lb., basis 60 per cent, was quoted for contracts on carload quantities. Sales of German *cyanide of soda*, 125-128 per cent, were recorded at 25c. per lb., with an exceedingly small supply of spot material around the market. Conditions in this chemical seem to be exceptionally bright and holders are backward in offering any round lots at present levels. Leading factors in *nitrite of soda* reports sales at 6¾c. per lb. The prevailing quotation was 6¾@7c. per lb., depending upon seller and quantity. There has been very little change in the attitude of consumers and operations have been confined chiefly to small quantities. Domestic *bleaching powder* in large drums is quoted at 21c. per lb., f.o.b. works. Sales of imported material have been made at 2c. per lb.,

ex-dock duty paid, while shipments from abroad are quoted at \$1.90 per 100 lb. The general demand for bleach from the various consuming trades has remained very active with paper mills leading the buying. Light soda ash, in single bags, is holding steady with sales reported at \$2.10@2.15 per 100 lb., depending upon the quantity. Sales of barrels are reported by dealers at \$2.45@2.50 per 100 lb. The feeling around the trade continues quite firm and a fair amount of business is passing at the above figures. Sales of small lots of carbon tetrachloride are reported at 11c. per lb. Larger quantities can be purchased below this figure, the price depending upon the quantity of the order. Prices on muriate of potash are slightly easier at \$38@40 per ton. Prices on spot nitrate of soda are somewhat firmer at \$2.25@2.30 per 100 lb.

COAL-TAR PRODUCTS

Conditions in the coal-tar products industry seem to be much brighter than at any time this year. There are still a few products where surplus stocks remain large and an undertone of weakness is noted on these, but on most of the other items these seems to be a healthier situation and holders show very little desire to loosen stocks at figures regardless of value. Manufacturers are operating in a more conservative manner, limiting their output to the actual requirements of the trade so that no stocks will accumulate. Buyers are showing more interest and are purchasing in larger quantities. Stocks of naphthalene are still heavy and holders are making concessions to realize some cash on their old stocks. The demand is very light, with prime white flakes offered at 63c. per lb. Producers' prices remain unchanged at former levels. Resale benzene is still very difficult to locate and where small lots can be obtained a premium must be paid. Odd lots in drums have sold at 40c. per gal. for the c.p. grade. Refiners quote 28@33c. per gal., but cannot make any deliveries for some time. Supplies of aniline oil are still plentiful, but production has been greatly curtailed and any pronounced buying will undoubtedly strengthen the market considerably. Sales at 17½@18c. per lb. were recorded, according to quantity and seller. Odd lot sales of beta-naphthol were reported at 31c. per lb., but the general asking price around the market is 32c. First hands quote up to 40c. per lb., but are willing to shade this figure on actual business. Supplies seem to be quite abundant. Makers of salicylic acid quote the technical grade at 18@20c. per lb. The U.S.P. is being sold by second hands at 19c. per lb. The low prices quoted by first hands on diethylaniline has stimulated business to some extent and inquiries were more noticeable than any time during the year. Sales were made at \$1@1.10 per lb., depending upon the quantity. Low priced dimethylaniline has been cleared off the market and the best offering now heard is 42c. per lb. Manufacturers continue to ask 45c. and upward, but are not placing any actual round lot business at these figures.

WAXES

The demand for the lower grades of beeswax was reported much brighter, with the market, steady in all directions. African crude on spot was held at 15@16c. per lb. with shipment goods quoted at 13½@14c. per lb. Brazilian crude closed unchanged at 22@24c. per lb. Pure refined wax on spot held at 36@40c. per lb. Offerings of candle-killa wax were noted at prices ranging from 24@25c. per lb., depending upon the quantity and seller. The demand was slow and the market barely steady. The call for carnauba wax was irregular and an easier feeling prevailed in various directions. Prices, at any rate, showed no important change, with the No. 2 North Country at 24@25c. per lb. and No. 3 North Country at 14½@15c. per lb. Small lots of Japan wax on spot brought as high as 26c. per lb. Offerings around the trade were light and sellers' views were quite firm, due to the recent advance in the cost of import. For round lots, the market closed at 24@25c. per lb. The demand for paraffine wax has once more fallen off so that refiners appeared quite anxious to meet the views of prospective buyers. Prices varied very little. The adverse exchange restricts any export business, while domestic consumers showed little disposition to buy in any quantity.

The Chicago Market

CHICAGO, Oct. 7, 1921.

Business in the general line of industrial chemicals continues very good and dealers appear well satisfied. While no really large transactions were reported, a very good volume of small orders was noticeable. There were practically no price changes reported and but little evidence of any shading of the present list.

INDUSTRIAL CHEMICALS

A firm tone still ruled in the market for caustic soda, although business was quieter. Supplies among second hands are small and 43c. for the solid 76 per cent and 43c. for the ground were the prevailing quotations. Soda ash is still very firm and supplies could not be located under \$2.60 per 100 lb. for material in cooperage. Sal soda seems to be moving quite well at \$1.65@1.70 per 100 lb., although no large orders were reported. Sal ammoniac is unchanged as to price and is not moving so well. Prime white material, 98-100 per cent, is available at 7½c. per lb. A fair movement of carbon bisulphide was noted in some quarters and supplies were available at 7@7½c. per lb. The formaldehyde market is rather featureless, with supplies plentiful at 12c. per lb. Glycerine is quiet and firm, the prevailing quotation being 14½c. per lb. for drums. Litharge is not so active and the price is unchanged at 7½c. per lb. A fair movement of lead acetate was noted and prices are firm at 13@13½c. per lb. for small or medium quantities. Caustic potash is firm and unchanged as to price. Small lots are available at 6½c. per lb. for the 88-92 per cent material. Bichromates are quiet and supplies are said to be light. The potash salt is available at 13@13½c. and the sodium at 9½c. per lb., single cask lots. Potassium permanganate is very quiet and but few sales are noted. The prevailing quotation for spot U.S.P. crystals was 24c. per lb. Sodium bicarbonate continues to move in a fair way and the price is unchanged at \$2.60 per 100 lb. The demand for sodium hyposulphite has fallen off somewhat, but quotations remain at \$4.05 per 100 lb. for the pea crystal. Acetate of soda is meeting with a fair request at 5½@6½c. per lb. Sodium fluoride continues active and the price is unchanged at 11@12c. per lb. Zinc chloride is moving well at 11½c. for the domestic and 9@9½c. for the imported.

The acids as a rule were quite firm and on some the inquiry was much improved. Acetic acid is very firm, with practically all of the second-hand material absorbed. The 28 per cent in barrels is quoted at \$2.65@2.75 per 100 lb. and the glacial at \$10.25@10.75. A good inquiry for oxalic acid is reported and the domestic material is available at 17c. per lb. It appears that about all of the foreign acid has been absorbed. Sulphuric acid is moving quite freely and is unchanged in price, makers quoting \$19@20 per ton in tank cars, f.o.b. works.

VEGETABLE OILS

Linseed oil is in a weak position, according to a prominent factor, who predicts lower prices in the near future. Several small sales were reported, but the inquiry was light. The boiled oil is quoted today at 81c. per gal. and the raw at 79c.

NAVAL STORES

The naval stores market appears to be quite firm and dealers are reporting a very good volume of business. Turpentine is moving in a very fair way at 79c. per gal. drum basis, material in cooperage 5c. higher. Rosin is firm and moving very well, the "G" grade being quoted at \$5.35 per 280 lb. in carlots.

The Iron and Steel Market

PITTSBURGH, Oct. 7, 1921.

Viewed as a whole, the steel market is probably improving somewhat in volume of demand, while prices on the whole are not declining and are barely stationary, showing rather a slight stiffening tendency. Nevertheless the situation is not as good as was to be expected for the first week in October.

Consideration of conditions in the different products that make up the steel market as a whole does not enable one to generalize as to the fundamental conditions obtaining in

industry and commerce, but is useful even if it shows a negative result. Easily sheets constitute the most finished steel line. The Steel Corporation's sheet department is this week operating at about 90 per cent, while the independents as a whole are probably averaging 75 per cent or more. This operation, however, is predicated upon the large volume of business booked recently, in anticipation of the price advance that has since been in effect. Tin plate comes next in point of production, with mills operating at between 60 and 70 per cent.

The wire mills are operating at rates from 50 to 65 per cent, but the production is largely seasonal in character, and there is probably some stocking by jobbers and retailers, since orders now being filled were placed before the recent advances in mill prices.

The pipe mills are operating at an average of between 40 and 50 per cent. The demand for standard steel pipe is described as fairly good, not very far from normal, but line pipe and oil country goods generally are in light request and on account of the season of the year there is little prospect of improvement.

Production of steel ingots is scarcely at more than 35 per cent of capacity. The average is held down by light operation of bar, shape, plate and rail mills. The lightness of rail production is easily understood. The railroads bought conservatively for this year and are not taking out all their deliveries, being short of funds. Dullness in plates and shapes is ascribable to there being little construction work involving these materials, though there is much building of garages and dwelling houses. The lightness of demand for bars is not so easily understood, when there is fair demand for pipe, sheets and wire. Buyers of finished steel have been quoted prices averaging not more than about 30 per cent above the average prices of 1913, making an index number of 130 comparing with the Bureau of Labor's index number of all commodities of 152 for August, against 148 for July, so that steel prices have been relatively low.

The recent advances in wire products and sheets involved a sales campaign in which mills were ready to book orders at the old prices, while buyers were convinced that prices were going to advance. The operations were quite successful in placing tonnage on mill books. For several weeks past a number of mills making bars, shapes and plates have been conducting similar campaigns, but the operation has not been signally successful. While buyers may have been willing in most cases to place contracts for the remainder of the year, subject to specification from time to time as needs arose, they evidently have not been in position to put much tonnage on books in actual shipping orders. While the tonnage desired has not accumulated, a mill here and there has been disposed to stiffen in prices nevertheless. All three products can still be bought at 1.60c., but there is more disposition to hold to 1.65c. for bars and 1.65c. or higher for plates and shapes. There are reports that sales have been made at 1.50c. or less, but these are probably incorrect in all cases.

SEMI-FINISHED STEEL

Quite generally the mills are now quoting \$32 on sheet bars, by the so-called "advance" from \$30. Sales had actually been made at less than \$30 and no transactions have definitely shown a price above \$30. Billets are altogether neglected, some mills not having even an asking price. Nominally they are about \$30, with \$32 for small billets.

PIG IRON

The local pig-iron market has been very quiet, but furnaces expect a little buying movement very shortly. This would probably bring in some idle furnaces, so that it is not certain prices would advance. We quote: Bessemer, \$20; basic, \$19.25@20; foundry, \$21, f.o.b. valley furnaces, freight to Pittsburgh being \$1.96. At a recent conference between iron and steel producers and railroad officials the sought-for reductions in ore, coke and limestone rates were denied, the assigned reason being that a general reduction in freight rates may possibly occur early next year.

Connellsville coke shows a stiffer tone and quotations are higher, though advances are not well supported thus far by sales. We quote: Spot furnace, \$2.35@2.50; contract furnace, \$2.50@2.75; spot foundry, \$4.25@4.75.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride.....	lb.	\$0.12 - \$0.12	\$0.40 - \$0.45
Acetone.....	lb.	2.75 - 3.00	13 - 13
Acid, acetic, 28 per cent.....	100 lbs.	5.50 - 5.75	3.25 - 3.50
Acetic, 56 per cent.....	100 lbs.		6.00 - 6.50
Acetic, glacial, 99 1/2 per cent, carboys.....	100 lbs.	10.50 - 11.00	11.25 - 10.50
Boric, crystals.....	lb.	12 - 13	13 - 14
Boric, powder.....	lb.	13 - 13 1/2	14 - 14 1/2
Citric.....	lb.		45 - 47
Hydrochloric.....	100 lb.	1.25 - 1.50	1.60 - 1.75
Hydrofluoric, 52 per cent.....	lb.	12 - 12 1/2	12 - 13
Lactic, 44 per cent tech.....	lb.	09 - 10	10 - 12
Lactic, 22 per cent tech.....	lb.	04 - 05	06 - 07
Molybdic, C.P.....	lb.	3.25 - 3.50	3.60 - 4.00
Muriatic, 20 deg. (see hydrochloric).....	lb.	06 - 06 1/2	06 - 07
Nitric, 40 deg.....	lb.	06 - 07	07 - 07 1/2
Nitric, 42 deg.....	lb.	16 - 16 1/2	16 - 17 1/2
Oxalic, crystals.....	lb.	13 - 13 1/2	14 - 18
Phosphoric, 50 per cent solution.....	lb.	20 - 25	27 - 35
Picric.....	lb.		1.75 - 1.90
Pyrogallol, resublimed.....	lb.		11.00 - 12.00
Sulphuric, 60 deg., tank cars.....	ton		13.00 - 15.00
Sulphuric, 60 deg., drums.....	ton	17.00 - 18.00	
Sulphuric, 66 deg., tank cars.....	ton	21.00 - 22.00	22.50 - 23.00
Sulphuric, 66 deg., drums.....	ton		
Sulphuric, 66 deg., carboys.....	ton		
Sulphuric, fuming, 20 per cent (oleum).....	ton	21.00 - 22.00	
Sulphuric, fuming, 20 per cent (oleum).....	ton	23.00 - 23.50	24.00 - 24.50
Sulphuric, fuming, 20 per cent (oleum).....	ton	31.00 - 32.00	33.00 - 34.00
Tannic, U. S. P.....	lb.		75 - 85
Tannic (tech.).....	lb.	45 - 48	50 - 55
Tartaric, imported crystals.....	lb.		27 - 28
Tartaric acid, imported, powdered.....	lb.		27 - 28
Tartaric acid, domestic.....	lb.		35
Tungstic, per lb. of WO.....	lb.		1.10 - 1.20
Alcohol, Ethyl.....	gal.		4.65 - 4.90
Alcohol, Methyl (see methanol).....	gal.		
Alcohol, denatured, 188 proof.....	gal.		35 - 36
Alcohol, denatured, 190 proof.....	gal.		37 - 38
Alum, ammonia, lump.....	lb.	03 - 03 1/2	04 - 04 1/2
Alum, potash, lump.....	lb.	03 - 04	04 - 04 1/2
Alum, chrome lump.....	lb.	10 - 11	11 - 12 1/2
Aluminum sulphate, commercial.....	lb.	02 - 02 1/2	02 - 02 1/2
Aluminum sulphate, iron free.....	lb.	03 - 03 1/2	03 - 04
Aqua ammonia, 26 deg., drums (750 lb.).....	lb.	07 - 07 1/2	08 - 08 1/2
Ammonia, anhydrous, cyl. (100-150 lb.).....	lb.	30 - 32	33 - 35
Ammonium carbonate, powder.....	lb.	07 - 07 1/2	08 - 09
Ammonium chloride, granular (white).....	lb.	06 - 06 1/2	06 1/2 - 07
Ammonium chloride, granular (gray).....	lb.	06 1/2 - 07	07 1/2 - 08
Ammonium nitrate.....	lb.	07 - 07 1/2	07 1/2 - 08 1/2
Amylacetate.....	gal.		3.25 - 3.50
Arsenic, white.....	gal.		2.50 - 3.00
Arsenic, sulphide, powdered (red arsenic).....	lb.	05 - 05 1/2	06 - 06 1/2
Barium chloride.....	ton	44.00 - 45.00	46.00 - 50.00
Barium dioxide (peroxide).....	lb.	20 - 21	22 - 23
Barium nitrate.....	lb.	07 - 08	08 - 09
Barium sulphate (precip.) (blanc fixe).....	lb.	04 - 04 1/2	04 1/2 - 05
Bleaching powder (see calc. hypochlorite).....	lb.		
Blue vitriol (see copper sulphate).....	lb.		
Borax (see sodium borate).....	lb.		
Bromine.....	lb.	27 - 28	28 - 30
Calcium acetate.....	100 lbs.	2.00 - 2.05	
Calcium carbide.....	lb.	04 - 04 1/2	05 - 05 1/2
Calcium chloride, fused, lump.....	ton	23.50 - 24.00	24.50 - 25.50
Calcium chloride, granulated.....	lb.	01 - 02	02 - 02 1/2
Calcium hypochloride (bleach g powder).....	100 lb.	2.50 - 2.60	2.70 - 3.25
Calcium peroxide.....	lb.		1.40 - 1.50
Calcium phosphate, tribasic.....	lb.		15 - 16
Camphor.....	lb.		70 - 72
Carbon bisulphide.....	lb.	06 - 06 1/2	07 - 07 1/2
Carbon tetrachloride, drums.....	lb.	10 - 10 1/2	11 - 12
Carbonyl chloride, (phosgene).....	lb.		60 - 75
Caustic potash (see potassium hydroxide).....	lb.		
Caustic soda (see sodium hydroxide).....	lb.		
Chlorine, gas, liquid-cylinders (100 lb.).....	lb.	08 - 09	09 - 10
Chloroform.....	lb.		38 - 43
Cobalt oxide.....	lb.		2.00 - 2.10
Copperas (see iron sulphate).....	lb.		
Copper carbonate, green precipitate.....	lb.	19 - 19 1/2	20 - 21
Copper cyanide.....	lb.		50 - 62
Copper sulphate, crystals.....	lb.	05 - 05 1/2	05 1/2 - 06
Cream of tartar (see potassium bitartrate).....	lb.		
Epsom salt (see magnesium sulphate).....	lb.		
Ethyl Acetate Com. 85%.....	gal.		1.00 - 1.10
Ethyl Acetate pure (acetic ether, 98% to 100%).....	lb.		40 - 42
Formaldehyde, 40 per cent.....	lb.	11 - 12	12 - 13
Fusel oil, ref.....	gal.		3.25 - 3.75
Fusel oil, crude.....	gal.		1.50 - 1.75
Glauber's salt (see sodium sulphate).....	lb.		15
Glycerine, C. P. drums extra.....	lb.		3.50 - 3.60
Iodine, resublimed.....	lb.		10 - 20
Iron oxide, red.....	lb.		20.00 - 23.00
Iron sulphate (copperas).....	ton	18.00 - 19.00	
Lead acetate.....	lb.		10 - 11
Lead arsenate, paste.....	lb.	09 - 09 1/2	10 - 11
Lead nitrate.....	lb.		15 - 20
Litharge.....	lb.	07 - 08	08 - 10
Lithium carbonate.....	lb.		1.30 - 1.40
Magnesium carbonate, technical.....	lb.	08 - 08 1/2	09 - 10
Magnesium sulphate, U. S. P.....	100 lb.	2.50 - 2.75	1.10 - 1.75
Magnesium sulphate, technical.....	100 lb.		66 - 68
Methanol, 95%.....	gal.		70 - 72
Methanol, 97%.....	gal.		12 - 12 1/2
Nickel Salt, double.....	lb.		14 - 14 1/2
Nickel salt, single.....	lb.		
Phosgene (see carbonyl chloride).....	lb.		
Phosphorus, red.....	lb.	40 - 41	42 - 45
Phosphorus, yellow.....	lb.		30 - 35
Potassium bichromate.....	lb.	11 - 11 1/2	11 - 12

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar).....	lb.	\$ - \$	\$0.25 - \$0.28
Potassium bromide, granular.....	lb.		14 - 20
Potassium carbonate, U. S. P.....	lb.	20 - 21	22 - 25
Potassium carbonate, 80-85%.....	lb.	04 - 04	05 - 06
Potassium chlorate, crystals.....	lb.	06 - 07	07 - 10
Potassium cyanide.....	lb.		26 - 28
Potassium hydroxide (caustic potash).....	lb.	05 - 05	05 - 06
Potassium iodide.....	lb.		2.60 - 2.75
Potassium nitrate.....	lb.	09 - 09	10 - 12
Potassium permanganate.....	lb.	20 - 21	22 - 23
Potassium prussiate, red.....	lb.	28 - 29	29 - 30
Potassium prussiate, yellow.....	lb.	20 - 20	21 - 22
Rochelle salts (see sodium potas tartrate)			
Salammoniac (see ammonium chloride)			
Sal soda (see sodium carbonate)			
Salt cake (bulk).....	ton		17.00 - 20.00
Silver cyanide.....	oz.		1.35 - 1.38
Silver nitrate.....	oz.		46 - 47
Soda ash, light.....	100 lb.	2.10 - 2.15	2.20 - 2.50
Soda ash, dense.....	100 lb.	2.35 - 2.40	2.45 - 2.70
Sodium acetate.....	lb.	04 - 04	04 - 05
Sodium bicarbonate.....	100 lb.	2.00 - 2.25	2.50 - 2.75
Sodium bichromate.....	lb.	07 - 07	08 - 08
Sodium bisulphate (nitre cake).....	ton	5.00 - 5.25	5.50 - 6.50
Sodium bisulphate powdered, U. S. P.....	lb.	04 - 05	05 - 06
Sodium borate (borax).....	lb.	05 - 06	06 - 07
Sodium carbonate (sal soda).....	100 lb.	1.75 - 1.90	2.00 - 2.25
Sodium chloride.....	lb.	07 - 07	08 - 08
Sodium cyanide.....	lb.	25 - 26	27 - 30
Sodium fluoride.....	lb.	10 - 11	11 - 12
Sodium hydroxide (caustic soda).....	100 lb.	4.00 - 4.10	4.15 - 4.75
Sodium hyposulphite.....	lb.		03 - 03
Sodium nitrite.....	lb.	06 - 07	07 - 07
Sodium peroxide, powdered.....	lb.	25 - 26	27 - 30
Sodium phosphate, dibasic.....	lb.	04 - 04	04 - 05
Sodium potassium tartrate (Rochelle salts).....	lb.		21 - 24
Sodium prussiate, yellow.....	lb.	13 - 13	13 - 13
Sodium silicate, solution (40 deg.).....	100 lb.	1.00 - 1.15	1.25 - 1.40
Sodium silicate, solution (60 deg.).....	lb.	02 - 03	03 - 03
Sodium sulphate, crystals (Glauber's salt).....	100 lb.	1.50 - 1.75	2.00 - 2.25
Sodium sulphide, fused, 60-62 per cent (conc).....	lb.	04 - 04	05 - 06
Sodium sulphite, crystals.....	lb.	03 - 04	04 - 04
Strontium nitrate, powdered.....	lb.	12 - 13	13 - 20
Sulphur chloride, red.....	lb.	05 - 05	05 - 06
Sulphur, crude.....	ton	18.00 - 20.00	
Sulphur dioxide, liquid, cylinders ex.....	lb.	08 - 08	09 - 10
Sulphur (sublimed), flour.....	100 lb.		2.25 - 3.10
Sulphur, roll (brimstone).....	100 lb.		2.00 - 2.75
Tin bichloride, 50 per cent.....	lb.	18 - 19	
Tin oxide.....	lb.		38 - 40
Zinc carbonate, precipitate.....	lb.	16 - 16	17 - 17
Zinc chloride, gran.....	lb.	09 - 09	10 - 11
Zinc cyanide.....	lb.	42 - 44	45 - 47
Zinc dust.....	lb.	11 - 11	11 - 12
Zinc oxide, XX.....	lb.	07 - 07	08 - 09
Zinc sulphate.....	100 lb.	3.00 - 3.25	3.30 - 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude.....	lb.	\$1.15 - \$1.20
Alpha-naphthol, refined.....	lb.	1.30 - 1.35
Alpha-naphthylamine.....	lb.	30 - 35
Aniline oil, drums extra.....	lb.	17 - 20
Aniline salts.....	lb.	24 - 26
Anthracene, 80% in drums (100 lb.).....	lb.	75 - 1.00
Benzaldehyde U. S. P.....	lb.	1.00 - 1.25
Benzidine, base.....	lb.	1.00 - 1.10
Benzidine sulphate.....	lb.	75 - 85
Benzoic acid, U. S. P.....	lb.	60 - 65
Benzoate of soda, U. S. P.....	lb.	52 - 55
Benzene, pure, water-white, in drums (100 gal.).....	gal.	27 - 32
Benzene, 90% in drums (100 gal.).....	gal.	25 - 28
Benzyl chloride, 95-97% refined.....	lb.	25 - 27
Benzyl chloride, tech.....	lb.	20 - 23
Beta-naphthol benzoate.....	lb.	3.50 - 4.00
Beta-naphthol, sublimed.....	lb.	70 - 75
Beta-naphthol, tech.....	lb.	32 - 35
Beta-naphthylamine, sublimed.....	lb.	1.90 - 2.00
Cresol, U. S. P., in drums (100 lb.).....	lb.	16 - 17
Ortho-cresol, in drums (100 lb.).....	lb.	25 - 27
Cresylic acid, 97-99%, straw color, in drums.....	gal.	70 - 75
Cresylic acid, 75-97%, dark, in drums.....	gal.	60 - 65
Cresylic acid, 50%, first quality, drums.....	gal.	45 - 50
Dichlorobenzene.....	lb.	06 - 09
Diethylaniline.....	lb.	1.00 - 1.15
Dimethylaniline.....	lb.	42 - 50
Dinitrobenzene.....	lb.	25 - 28
Dinitrochlorobenzene.....	lb.	25 - 30
Dinitronaphthalene.....	lb.	32 - 40
Dinitrophenol.....	lb.	37 - 40
Dinitrotoluene.....	lb.	25 - 30
Dip oil, 25%, ear lots, in drums.....	gal.	30 - 35
Diphenylamine.....	lb.	60 - 70
H-acid.....	lb.	1.10 - 1.20
Meta-phenylenediamine.....	lb.	1.15 - 1.20
Monochlorobenzene.....	lb.	12 - 14
Monooethylaniline.....	lb.	1.50 - 1.60
Naphthalene crushed, in bbls.....	lb.	05 - 07
Naphthalene, flake.....	lb.	05 - 08
Naphthalene, balls.....	lb.	08 - 09
Naphthionic acid, crude.....	lb.	70 - 75
Nitrobenzene.....	lb.	12 - 15
Nitro-naphthalene.....	lb.	30 - 35
Nitro-toluene.....	lb.	15 - 17
Ortho-amidophenol.....	lb.	3.00 - 3.10
Ortho-dichlorobenzene.....	lb.	15 - 20
Ortho-nitrobenzene.....	lb.	75 - 80
Ortho-nitrophenol.....	lb.	15 - 20
Ortho-nitro-toluene.....	lb.	21 - 25
Para-amidophenol, base.....	lb.	1.40 - 1.45
Para-amidophenol, HCl.....	lb.	1.70 - 1.80
Para-dichlorobenzene.....	lb.	15 - 20
Paranitroaniline.....	lb.	79 - 82
Para-nitrotoluene.....	lb.	80 - 85
Para-phenylenediamine.....	lb.	1.70 - 1.75
Para-toluidine.....	lb.	1.25 - 1.40
Phthalic anhydride.....	lb.	40 - 50

Phenol, U. S. P., drums.....	lb.	08 - 10
Pyridine.....	gal.	2.00 - 3.50
Resoreinol, technical.....	lb.	1.50 - 1.60
Resoreinol, pure.....	lb.	2.00 - 2.25
Salicylic acid, tech., in bbls.....	lb.	18 - 20
Salicylic acid, U. S. P.....	lb.	17 - 22
Salol.....	lb.	60 - 70
Solvent naphtha, water-white, in drums, 100 gal.....	gal.	25 - 28
Solvent naphtha, crude, heavy, in drums, 100 gal.....	gal.	14 - 16
Sulphanilic acid, crude.....	lb.	27 - 30
Tolidine.....	lb.	1.30 - 1.35
Toluidine, mixed.....	lb.	43 - 45
Toluene, in tank cars.....	gal.	25 - 28
Toluene, in drums.....	gal.	28 - 31
Xyldines, drums, 100 gal.....	lb.	40 - 45
Xylene, pure, in drums.....	gal.	40 - 45
Xylene, pure, in tank cars.....	gal.	45 - 45
Xylene, commercial, in drums, 100 gal.....	gal.	33 - 35
Xylene, commercial, in tank cars.....	gal.	30 - 35

Waxes

Prices based on original packages in large quantities.

Bayberry Wax.....	lb.	\$0.19 - \$0.20
Beeswax, refined, dark.....	lb.	24 - 25
Beeswax, refined, light.....	lb.	28 - 30
Beeswax, white pure.....	lb.	36 - 42
Candelilla wax.....	lb.	24 - 25
Carnauba, Florida.....	lb.	48 - 50
Carnauba, No. 2, North Country.....	lb.	24 - 25
Carnauba, No. 3, North Country.....	lb.	14 - 15
Japan.....	lb.	24 - 26
Montan, crude.....	lb.	05 - 05
Paraffine waxes, crude match wax (white) 105-110 m.p.....	lb.	03 - 03
Paraffine waxes, crude, scale 124-126 m.p.....	lb.	02 - 02
Paraffine waxes, refined, 118-120 m.p.....	lb.	03 - 03
Paraffine waxes, refined, 125 m.p.....	lb.	03 - 03
Paraffine waxes, refined, 128-130 m.p.....	lb.	03 - 04
Paraffine waxes, refined, 133-135 m.p.....	lb.	04 - 05
Paraffine waxes, refined, 135-137 m.p.....	lb.	05 - 06
Stearic acid, single pressed.....	lb.	09 - 10
Stearic acid, double pressed.....	lb.	10 - 11
Stearic acid, triple pressed.....	lb.	11 - 11

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on earload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.....	280 lb.	\$5.55 - 5.65
Rosin E-I.....	280 lb.	5.75 - 6.25
Rosin K-N.....	280 lb.	6.35 - 6.75
Rosin W. G.-W. W.....	280 lb.	6.90 - 7.40
Wood rosin, bbl.....	280 lb.	6.25 - 6.75
Spirits of turpentine.....	gal.	75 - 75
Wood turpentine, steam dist.....	gal.	73 - 73
Wood turpentine, dest. dist.....	gal.	72 - 72
Pine tar pitch, bbl.....	200 lb.	6.50 - 6.50
Tar, kiln burned, bbl. (500 lb.).....	bbl.	11.00 - 11.00
Retort tar, bbl.....	500 lb.	11.00 - 11.00
Rosin oil, first run.....	gal.	35 - 35
Rosin oil, second run.....	gal.	37 - 37
Rosin oil, third run.....	gal.	44 - 44
Pine oil, steam dist., sp.gr., 0.930-0.940.....	gal.	\$1.90 - 1.90
Pine oil, pure, dest. dist.....	gal.	1.50 - 1.50
Pine tar oil, ref., sp.gr. 1.025-1.035.....	gal.	1.46 - 1.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.....	gal.	35 - 35
Pine tar oil, double ref., sp.gr. 0.965-0.990.....	gal.	75 - 75
Pine tar, ref., thin, sp.gr., 1.080-1.060.....	gal.	35 - 35
Turpentine, crude, sp.gr., 0.900-0.970.....	gal.	1.25 - 1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990.....	gal.	35 - 35
Pine wood creosote, ref.....	gal.	52 - 52

Solvents

73-76 deg., steel bbls. (85 lb.).....	gal.	\$0.37 - 0.37
70-72 deg., steel bbls. (85 lb.).....	gal.	35 - 35
68-70 deg., steel bbls. (85 lb.).....	gal.	34 - 34
V. M. and P. naphtha, steel bbls. (85 lb.).....	gal.	23 - 23

Fertilizers

Ammonium sulphate, bulk and d. bags.....	100 lb.	\$2.15 - 2.50
Blood, dried, f.o.b. N. Y.....	unit	4.00 - 4.00
Bone, 3 and 50, ground, raw.....	ton	30.00 - 32.00
Cyanamide, f.o.b. works.....	unit	4.50 - 4.50
Fish scrap, dom., dried, f.o.b. works.....	unit	2.90 - 3.00
Nitrate soda.....	100 lb.	2.25 - 2.30
Tankage, high grade, f.o.b. Chicago.....	unit	3.00 - 3.10
Phosphate rock, f.o.b. mines, Florida pebble, 68-72 p.c.....	ton	5.00 - 7.50
Tennessee, 78-80 p.c.....	ton	8.00 - 9.00
Potassium murate, 80 p.c.....	ton	38.00 - 40.00
Potassium sulphate.....	unit	1.20 - 1.25

Crude Rubber

Para-Upriver fine.....	lb.	\$0.21 - 0.21
Upriver coarse.....	lb.	11 - 12
Upriver caucho ball.....	lb.	11 - 12
Plantation—First latex crepe.....	lb.	15 - 15
Ribbed smoked sheets.....	lb.	15 - 15
Brown crepe, thin, clean.....	lb.	15 - 15
Amber crepe No. 1.....	lb.	17 - 17

Oils

VEGETABLE

The following prices are f.o.b. New York for earload lots.

Castor oil, No. 3, in bbls.....	lb.	\$0.10 - \$0.10
Castor oil, AA, in bbls.....	lb.	11 - 11
China wood oil, in bbls. (f.o.b. Pac. coast).....	lb.	14 - 15
Cocanut oil, Ceylon grade, in bbls.....	lb.	09 - 10
Cocanut oil, Cochinchina grade, in bbls.....	lb.	10 - 10
Corn oil, crude, in bbls.....	lb.	09 - 09
Cottonseed oil, crude (f. o. b. mill).....	lb.	07 - 08
Cottonseed oil, summer yellow.....	lb.	09 - 10
Cottonseed oil, winter yellow.....	lb.	10 - 10

Linseed oil, raw, ear lots (domestic)	gal.	67	—	68
Linseed oil, raw, tank cars (domestic)	gal.	62	—	63
Linseed oil, in 5-bbl lots (domestic)	gal.	70	—	71
Olive oil, Denatured	gal.	\$1.10	—	\$1.20
Palm, Lagos	lb.	07	—	07
Palm, Niger	lb.	06	—	06
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	08	—	08
Peanut oil, refined, in bbls.	lb.	11	—	11
Rapeseed oil, refined in bbls.	gal.	90	—	91
Rapeseed oil, blown, in bbls.	gal.	92	—	94
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	08	—	08
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	07	—	07

FISH

Light pressed menhaden	gal.	\$0.40	—	—
Yellow bleached menhaden	gal.	42	—	—
White bleached menhaden	gal.	44	—	—
Blown menhaden	gal.	48	—	—

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	\$24.00	—	30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	20.00	—	24.00
Barytes, crude, 88% @ 94% ba., Kings Creek	net ton	10.00	—	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00	—	24.00
Barytes, crude, first grade, Missouri	net ton	7.00	—	—
Blanc fixe, dry	lb.	04	—	04
Blanc fixe, pulp	net ton	45.00	—	55.00
Casein	lb.	07	—	10
Chalk, Precipitated, domestic, extra light	lb.	04	—	05
Chalk, Precipitated, domestic, light	lb.	04	—	04
Chalk, Precipitated, domestic, heavy	lb.	03	—	04
Chalk, Precipitated, English, extra light	lb.	04	—	05
Chalk, Precipitated, English, light	lb.	04	—	05
Chalk, Precipitated, English, dense	lb.	04	—	04
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50	—	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00	—	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	13.00	—	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	13.00	—	20.00
China clay (kaolin), imported, lump	net ton	12.00	—	20.00
China clay (kaolin), imported, powdered	net ton	25.00	—	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00	—	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50	—	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00	—	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00	—	30.00
Fullers earth, f.o.b. Mines	net ton	16.00	—	17.00
Fullers earth, granular, f.o.b. Pa.	net ton	15.00	—	18.00
Fullers earth, powdered, f.o.b. Fla.	net ton	18.00	—	—
Fullers earth, imported, powdered	net ton	24.00	—	27.00
Graphite, Ceylon lump, first quality	lb.	06	—	07
Graphite, Ceylon chip	lb.	04	—	05
Graphite, high grade amorphous crude	lb.	00	—	02
Kieselguhr, f.o.b. mines, Cal.	per ton	40.00	—	—
Kieselguhr, f.o.b. N. Y.	per ton	61.00	—	—
Magnesite, calcined	per ton	66.00	—	70.00
Pumice stone, imported	lb.	03	—	04
Pumice stone, domestic, lump	lb.	05	—	05
Pumice stone, domestic, ground	lb.	06	—	07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	—	—	10.00
Quartz (acid tower) 1 1/2 in., f.o.b. Baltimore	net ton	—	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	—	—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange fine	lb.	64	—	65
Shellac, orange superfine	lb.	66	—	68
Shellac, A. C. garnet	lb.	50	—	52
Shellac, T. N.	lb.	56	—	57
Soapstone	ton	12.00	—	15.00
Sodium chloride	long ton	12.50	—	13.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00	—	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.50	—	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00	—	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50	—	11.00
Talc, imported	ton	30.00	—	40.00
Talc, California talcum powder grade	ton	18.00	—	25.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton	\$50.00	—	—
Carborundum refractory brick, 9-in. { less than earlot { earlot lots	1,000	1250.00	—	—
Chrome brick, f.o.b. Eastern shipping points	net ton	52-55	—	—
Chrome cement, 40-45% Cr ₂ O ₃	net ton	30-32	—	—
Chrome cement, 40-45% Cr ₂ O ₃ , sacks, in ear lots, f.o.b. Eastern shipping points	net ton	33-35	—	—
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	35-40	—	—
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	30-35	—	—
Magnesite brick, 9-in. straight	net ton	65-70	—	—
Magnesite brick, 9-in. arches, wedges and keys	net ton	77	—	—
Magnesite brick, soaps and splits	net ton	98	—	—
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000	40-42	—	—
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000	42-45	—	—
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa.	1,000	35-38	—	—

Ferro-Alloys

All f.o.b. Works

Ferro-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	\$200.00	—	\$225.00
Ferrocchrome per lb. of Cr. contained, 6-8% carbon, carlots	lb.	11	—	—
Ferrocchrome per lb. of Cr. contained, 4-6% carbon, carlots	lb.	11	—	12
Ferromanganese, 76-80% Mn, domestic	gross ton	60.00	—	63.00
Ferromanganese, 76-80% Mn, English & German	gross ton	60.00	—	63.00
Spiegelisen, 18-22% Mn	gross ton	25.00	—	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25	—	—
Ferrosilicon, 10-15%	gross ton	38.00	—	40.00
Ferrosilicon, 50%	gross ton	60.00	—	65.00
Ferrosilicon, 75%	gross ton	130.00	—	135.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	40	—	45
Ferroumranium, 35-50% of U, per lb. of U content	lb.	6.00	—	—
Ferrovandium, 30-40% per lb. of contained V	lb.	4.25	—	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	\$8.00	—	\$10.00
Chrome ore, Calif. concentrates, 50% min. Cr ₂ O ₃	ton	24.00	—	26.00
Chrome ore, 50% Cr ₂ O ₃ , f.o.b. Atlantic seaboard	ton	24.00	—	26.00
Coke, foundry, f.o.b. ovens	net ton	4.25	—	4.50
Coke, furnace, f.o.b. ovens	net ton	3.25	—	3.50
Coke, petroleum, refinery, Atlantic seaboard	net ton	12.00	—	13.00
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	15.00	—	—
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00	—	22.00
Ilmenite, 52% TiO ₂ , per lb. ore	lb.	01	—	01
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	20	—	21
Manganese ore, chemical (MnO ₂)	net ton	50.00	—	55.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂ , N. Y.	lb.	55	—	60
Monazite, per unit of ThO ₂ , c.i.f. Atlantic seaport	unit	30.00	—	—
Pyrites, Spanish, fines, c.i.f. Atlantic seaport	unit	12	—	12
Pyrites, furnace size, c.i.f. Atlantic seaport	unit	13	—	13
Pyrites, domestic, fines, f.o.b. mines, Ga.	unit	11	—	12
Rutile, 95% TiO ₂ per lb. ore	lb.	15	—	—
Tungsten, scheelite, 60% WO ₃ and over, per unit of WO ₃ (nominal)	unit	2.75	—	3.00
Tungsten, Wolframite, 60% WO ₃ and over, per unit of WO ₃ , N. Y. C.	unit	3.00	—	3.25
Uranium ore (carnotite) per lb. of U ₃ O ₈	lb.	1.25	—	1.75
Uranium oxide, 96% per lb. contained U ₃ O ₈	lb.	2.25	—	2.50
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium ore, per lb. of V ₂ O ₅ contained	lb.	1.00	—	—
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	04	—	13

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	12.50
Aluminum, 98 to 99 per cent	24.50@25
Antimony, wholesale lots, Chinese and Japanese	4.70@4.80
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, sheet and blanks	35.00
Monel metal, ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, 8 rail	26.75@27.00
Lead, New York, spot	4.70
Lead, E. St. Louis, spot	4.50
Zinc, spot, New York	5.00@5.05
Zinc, spot, E. St. Louis	4.60

OTHER METALS

Silver (commercial)	oz.	\$0.70
Cadmium	lb.	1.00-1.25
Bismuth (500 lb. lots)	lb.	1.50@1.55
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	78.00
Iridium	oz.	150.00-170.00
Palladium	oz.	55.00-60.00
Mercury	75 lb.	38.00-39.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	19.50
Copper bottoms	27.00
Copper rods	18.00@18.75
High brass wire	15.75
High brass rods	13.25
Low brass wire	17.25
Low brass rods	17.25
Brazed brass tubing	25.00
Brazed bronze tubing	29.75
Seamless copper tubing	19.50
Seamless high brass tubing	18.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	Cleveland	Chicago
Copper, heavy and crucible	9.50@10.00	9.25	9.50
Copper, heavy and wire	9.00@9.25	8.50	8.50
Copper, light and bottoms	7.50@8.00	7.50	7.25
Lead, heavy	3.25@3.50	3.25	3.25
Lead, tea	2.25@2.35	2.25	2.25
Brass, heavy	4.25@4.50	4.50	5.00
Brass, light	3.25@3.50	3.25	3.50
No. 1 yellow brass turnings	4.00@4.25	4.25	4.50
Zinc	2.00@2.25	2.00	2.25

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by 1/2 in. and larger, and plates 1/2 in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	\$2.88	\$2.88	\$2.88
8-ft steel bars	2.78	2.78	2.78
Soft steel bar shapes	2.78	2.78	2.78
Soft steel bands	3.42	3.48	3.48
Plates, 1/2 to 1 in. thick	2.88	2.88	2.88

*Add 15¢ per 100 lb. for trucking to Jersey City and 10¢ for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arkansas

PENTERS BLUFF—The American Manganese Co., 57 East Jackson Boulevard, Chicago, Ill., is reported to have plans under way for the erection of a new reduction plant in the vicinity of Penters Bluff, for the production of pulverized limestone. The plant is estimated to cost in excess of \$500,000. Manganese properties will also be operated in this district.

California

LONG BEACH—The California-Mexican Oil & Refining Co., Los Angeles, Vernon Dumas, head, is considering the construction of a new oil refinery in the vicinity of Long Beach, estimated to cost about \$450,000.

WILMINGTON—The Union Oil Co., Union Oil Bldg., Los Angeles, will break ground at once for the erection of its proposed new 3-story building at Wilmington, Los Angeles harbor. It will be 110 x 144 ft., and is estimated to cost \$250,000. A large laboratory for testing work will be installed. Ralph J. Reed is chief engineer.

Connecticut

WEST HAVEN—The West Haven Oil Co. has plans under way for the erection of new buildings at Elm and Water Sts., for general works service, to include tanks and other accessory equipment. Dwight E. Smith, Liberty Bldg., New Haven, is architect.

Illinois

CHICAGO—The National Rosin, Oil & Size Co., 3001-17 West Forty-seventh St., has filed plans for the extensions and improvements in its plant to cost about \$12,000.

CHICAGO—The Kaestner & Hecht Co., 500 Throop St., is taking bids for the erection of an addition to its foundry at Blackhawk and Cherry Sts., used for machinery and other metal casting production, to cost about \$30,000, including improvements in the present structure. Frank D. Chase, Inc., 645 Michigan Ave., is architect and engineer.

CHICAGO—The Oil & Chemical Corp., 4650 Iowa St., has acquired the entire block of property at Kirkpatrick Ave., Iowa and Walton Sts., totaling 248 x 504 ft. The company is now using a portion of the site and the remainder will be utilized for expansion. The property at one time was occupied by the Reedy Foundry Co. H. T. Dorington is secretary.

Kentucky

COVINGTON—The Michaels' Art Bronze Co., 230 Scott St., will commence the immediate erection of a 4-story and basement addition to its plant, 45 x 65 ft., to cost about \$40,000. F. I. Michaels is president.

Maryland

BALTIMORE—The Barclay Petroleum Co., 35 Wall St., New York, N. Y., is considering plans for the erection of a new oil refinery in the vicinity of Baltimore. The proposed plant will be equipped for operation under a centrifugal system of refining.

BALTIMORE—About \$100,000 will be expended by the Meadowbrook Dye Works, Inc., for machinery for installation at its proposed new plant on O'Donnell St., near Third St., comprising the former property of the Gunther Brewery. The building is 1-story, 96 x 140 ft., located on a site, 200 x 204 ft. The company was organized recently with a capital of \$200,000, and office at 523 Equitable Bldg.

BALTIMORE—The property of the National Vinegar Corp., St. Helena, near Baltimore, has been acquired by Emmet F. Sheridan and associates, who have taken possession. The property consists of a main 4-story building, 60 x 80 ft., with 2-story structure, 80 x 80 ft., and smaller

buildings. The new owners are forming a corporation to operate the plant for the manufacture of vinegar and byproducts. A number of improvements and extensions will be made, with the installation of machinery, estimated to cost about \$100,000. Plans have been filed for the immediate erection of a 2-story addition, to cost \$12,000. The former plant capacity will be doubled.

BALTIMORE—The Red "C" Oil Mfg. Co., Keyser Bldg., has had plans prepared for the erection of a new building at the Key Highway and Lawrence St., for general works service. W. H. Fehsenfeld is president.

Massachusetts

EASTHAMPTON—The Easthampton Foundry Co., Railroad St., has commenced the erection of a new 1-story foundry, 40 x 50 ft., with two wing extensions, 16 x 20 ft. The structure will cost about \$30,000. L. A. Moackel is president.

CHARLESTOWN—The Masury-Young Co., 198 Milk St., Boston, manufacturer of olive oil products, oil compounds, etc., has awarded a contract to the National Engineering Co., Boston, for the erection of a new 3-story plant on Roland St., Charlestown, 34 x 72 ft. A. D. Little, Inc., Cambridge, Mass., is engineer.

CHELSEA—The Revere Rubber Co. has had plans prepared for the erection of an addition to its plant to cost about \$20,000. Lockwood, Greene & Co., 245 State St., Boston, are architects.

Michigan

MANISTEE—Ruggles & Rademaker, 381 River St., have construction under way for a new salt manufacturing plant to cost in excess of \$500,000, with machinery. F. W. Perkins, company address, is architect.

New Jersey

CAMDEN—The Camden Pottery Co., Mt. Vernon and Orchard Sts., manufacturer of sanitary earthenware products, has construction under way on a new 2-story addition, 30 x 72 ft., at Orchard and Chestnut Sts., to cost about \$30,000. T. M. Dobbins is president.

New York

CORNING—The Corning Brick, Terra Cotta & Tile Co. has commenced the rebuilding of its plant, recently destroyed by fire with loss in excess of \$75,000. M. E. Gregory is president.

BUFFALO—The Dunlop Tire Corp., River Road, is planning to inaugurate operations at its new plant, recently completed, early in January, with a working force of about 2,500 men. The plant when entirely completed will represent an investment of close to \$20,000,000. P. D. Saylor is general manager.

BROOKLYN—Simon Garber & Sons, 1876 Pitkin Ave., manufacturer of oil products, have awarded a contract to the Turner Construction Co., 242 Madison Ave., New York, for the erection of a new 1-story building at Junius St. and Sutter Ave., to cost about \$200,000.

Ohio

NEWARK—The Leonard Oil Gas Co. is completing plans for the erection of a new oil refinery on East Street, estimated to cost about \$200,000 with machinery. The Rust Engineering Co., 1901 Fifth Ave., Pittsburgh, Pa., is engineer. J. W. Leonard is president.

CANTON—The Canton Oxygen Co., 1339 Yale Ave., N.W., manufacturer of commercial oxygen products, is having plans prepared for the erection of a new 1-story plant on Louisville Road, 47 x 90 ft. W. L. Stolzenbach is president. M. H. Miller, 319 McKinley Ave., S.W., is engineer.

Oklahoma

HENRYETTA—The Henryetta Glass & Mfg. Co. has awarded a contract for the erection of its proposed new local plant and construction will be commenced at once. A list of equipment to be installed

has been prepared, to include spraying machines, molds, mechanical fans and general manufacturing equipment. The new plant will specialize in the manufacture of chimneys, globes, shades, automobile lens and kindred products. The company was organized recently with a capital of \$50,000. H. L. Chambers is head.

Oregon

PORTLAND—The Columbia Tire Co., 1401 Northwest Bank Bldg., will soon call for bids for the erection of a new 2-story plant, 300 ft. wide, with four wings, extending to the rear, each 90 ft. long. It is estimated to cost about \$100,000. R. A. Wurzburg is head.

Pennsylvania

PHILADELPHIA—F. W. Tunnell & Co., 15 North Fifth St., manufacturer of fertilizer products, has awarded a contract to the Austin Co., Bulletin Bldg., for the erection of a new plant on Wheatshaf Lane, 1-story, 95 x 250 ft., estimated to cost about \$125,000. F. H. Tunnell is president.

EAST STROUDSBURG—The Nitroloid Co. has commenced operations at the former plant of the East Stroudsburg Glassware Co., recently acquired, for the manufacture of sheet celluloid and kindred products.

PHILADELPHIA—The United Chemical & Industrial Corp., Widener Bldg., has acquired a substantial interest in the Salts & Chemicals, Ltd., Kitchener, near Ottawa, Ont. The company will conduct certain operations, and plans to increase the capacity of the plant. Walter Whetstone is treasurer.

PITTSBURGH—The Air Reduction Co., 120 Broadway, New York, N. Y., manufacturer of commercial oxygen, etc., has filed plans for the first unit of its proposed new plant at 1100-16 Ridge Ave., to cost about \$60,000.

Tennessee

CHATTANOOGA—The Signal Mountain Portland Cement Co., James Bldg., will take bids during November for its proposed new local plant, estimated to cost in excess of \$500,000.

Texas

GROESBECK—The Magnolia Petroleum Co., Dallas, is planning for extensions in its plant at Groesbeck to cost in excess of \$500,000. A new pumping plant will be constructed and new tanks installed in the storage department of the works. E. A. Latimer is manager.

HOUSTON—The Ligol Chemical Co. has commenced the erection of a new plant on the Buffalo Bayou for the manufacture of liquid soaps, metal paint and affiliated products. It is proposed to commence operations at an early date. J. W. Crotty is president.

HOUSTON—The Sinclair Refining Co. is planning for the rebuilding of the portion of its plant on the Houston Ship Channel, recently destroyed by fire with loss estimated at about \$50,000.

Virginia

NORTH HOLSTON—The Southern Gypsum Co. is planning for the installation of crushing and other machinery at its plant. The company recently increased its capital to \$750,000 for expansion. Frank A. Wilder is president.

PULASKI—The General Chemical Co., 25 Broad St., New York, N. Y., will resume operations immediately at its local acid plant, placing two units in service, and giving employment to about 50 men. The plant has been shut down since March. It is expected to resume production in other departments at an early date.

West Virginia

PRINCETON—The Princeton Brick Co. is planning for extensions and improvements at its plant to double the present capacity. New machinery will be installed.

Washington

CHESTER—The Standard Stoneware Co. is completing plans for the erection of a new pottery for the manufacture of high-grade ware. It is proposed to break ground in October. Paul Seidel is president.

Wisconsin

MILWAUKEE—The J. Greenebaum Tanning Co., North Milwaukee, will take bids at once for the erection of a new 2-story tannery addition, 45 x 70 ft., estimated to cost about \$30,000.

Capital Increases, Etc.

THE KINGSTON PAPER CO., Little Falls, N. Y., has filed notice of change of name to the Niagara Felt & Paper Co. The latter organization has commenced the erection of a new plant on Sugar St., Niagara Falls, N. Y., to cost about \$300,000.

THE CARTHAGE BOARD & PAPER CO., Carthage, Ind., has filed notice of change of name to the American Paper Products Co.

THE PARAMOUNT RUBBER PRODUCTION CO. of New York, Waterloo, N. Y., has filed notice of dissolution under state laws.

THE HARRIS SOAP CO., 18 Stetson St., Buffalo, N. Y., has filed notice of increase in capital from \$35,000, to \$100,000.

THE PRINCE'S METALLIC PAINT CO., Allentown, Pa., has been adjudged an involuntary bankrupt.

THE MARYLAND VEGETABLE OIL CO., Fifteenth St. and Sixth Ave., Canton, Baltimore, Md., has arranged for a stock issue of \$2,250,000. John F. Nisaly is president.

THE BARAHONA SUGAR CO., 129 Front St., New York, N. Y., has filed notice of increase in capital from \$16,000,000 to \$18,300,000.

THE BOONE OIL CO., 11 Broadway, New York, N. Y., has filed notice of increase in capital from \$7,000,000 to \$13,000,000.

A petition in bankruptcy has been filed against the **BEVEL GLASS CO.**, 24 Downing St., New York, N. Y., manufacturer of mirrors, etc.

THE CARTHAGE SULPHITE PULP & PAPER CO., Carthage, N. Y., has arranged for a bond issue of \$600,000, for general operations, improvements, etc.

THE ALUMINUM CO. OF AMERICA, Oliver Bldg., Pittsburgh, Pa., has arranged for a bond issue of \$18,000,000, for general operations, financing, etc.

New Companies

THE DETROIT UNIVERSAL SOLVENT CO., Detroit, Mich., has been incorporated with a capital of \$25,000, to manufacture chemicals, paints, oils, etc. The incorporators are Wallace A. Armstrong, David S. Boyd and Harry W. Summers, 2691 Wreford Ave., Detroit.

THE AMIQOID CO., Boston, Mass., has been incorporated with a capital of \$500,000, to manufacture leather products. Frank A. Kamp is president, and Thomas M. Clafin, Brookline, Mass., treasurer.

THE PARK CHEMICAL CO., Brooklyn, N. Y., has been incorporated with a capital of \$100,000, to manufacture chemicals and chemical byproducts. The incorporators are J. A. and T. F. McGuinn, and J. Amico. The company is represented by E. J. Flanagan, 44 Court St., Brooklyn.

THE BENTON MFG. CO., 2130 West Van Buren St., Chicago, Ill., has been incorporated with a capital of \$5,000, to manufacture chemicals and chemical byproducts. The incorporators are Rupert Perbchner, Sidney Bisco and Solomon P. Roderick.

THE ALPHA PAPER PRODUCTS CORP., Brooklyn, N. Y., has been incorporated with a capital of \$5,000, to manufacture paper goods. The incorporators are W. G. Golden, M. Hoosack and F. D. McGarey, 51 Chambers St., New York.

THE ELECTRIC FOUNDRY & ENGINEERING CO., Wilmington, Del., has been incorporated with a capital of \$100,000, to manufacture steel and other metal castings. The company is represented by the Capital Trust Co. of Delaware, Dover, Del.

THE HERCULES SAPONA CO., INC., Boston, Mass., has been incorporated with a capital of 1,000 shares of stock, no par value, to manufacture chemicals and chemical byproducts. J. Sidney Stone is president; and Herbert P. Mason, Saugus, Mass., treasurer.

E. T. STILLE & CO., INC., 3422 Lincoln Ave., Chicago, Ill., has been incorporated with a capital of \$20,000 to manufacture varnish, shellac, paint, etc. The incorporators are E. T. and D. E. Stille, and W. W. Bennett.

MCCOMB BROS., INC., Scarsdale, N. Y., has been incorporated with a capital of \$25,000 to manufacture chemicals and affiliated products. The incorporators are S. and J. B. McComb, and F. Winters, Scarsdale. The company is represented by Jacob Axelrad, 365 Broadway.

THE TEHMESCAL OIL CO., Los Angeles, Cal., has been incorporated with a capital of \$500,000, to manufacture petroleum products. The incorporators are L. K.

Adams, J. C. Gillham and C. C. Rich. The company is represented by Claud B. Andrews, 730 Merchants National Bank Bldg., Los Angeles.

THE BOULEVARD CHEMICAL CO., 381 Forest St., Jersey City, N. J., has filed notice of organization to manufacture chemicals and chemical byproducts. Robert H. Cohen, 42 Clendenny Ave., Jersey City, heads the company.

THE NASHVILLE PULP & PAPER CO., Nashville, Tenn., has been incorporated under Delaware laws with capital of \$1,250,000, to manufacture paper products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington, Del.

THE JOHNSON HIGH TEST OIL CO., 503 State Bank Bldg., Freeport, Ill., has been incorporated with a capital of \$50,000, to manufacture petroleum products and byproducts. The incorporators are Harold W. Johnson, Edward J. Murray and Charles E. Johnson.

THE PERFEX PACKING FIBRE BOX CO., New York, N. Y., has been incorporated with a capital of \$9,000, to manufacture fiber goods. The incorporators are L. Smith, Jr., B. I. Cantor and C. M. Hiesiger. The company is represented by Kleiner, Britwitz & Nadli, 399 Broadway.

THE SOLE WHITE LEATHER CO., Salem, Mass., has been incorporated with a capital of \$50,000, to manufacture leather products. Harold E. Hadley is president; and Thomas A. O'Keefe, 178 Lowell St., Peabody, Mass., treasurer.

THE NEW CORUNNA BRICK CO., Detroit, Mich., has been incorporated with a capital of \$25,000, to manufacture brick and other burned clay products. The incorporators are Henry F. Horn, Howard G. Harris and Christian P. Steinhelser, 1110 East Grand Boulevard, Detroit.

THE EL DORADO OIL REFINING CO., Tulsa, Okla., has been incorporated with a capital of \$500,000, to manufacture refined petroleum products. The incorporators are L. F. Severson, Tulsa; G. W. and L. F. Merrill, both of Texarkana, Tex.

THE ARKANSAS CO., New York, N. Y., has been incorporated with a capital of \$10,000, to manufacture oils, chemicals and kindred products. The incorporators are M. Braham E. F. Katzenhuber and A. A. Kelley. The company is represented by H. H. Nelman, 160 Broadway, New York.

THE KUEHN-CASWELL CO., New York, N. Y., has been incorporated with a capital of \$50,000, to manufacture insulating materials, compounds, etc. The incorporators are W. G. Kuehn, E. T. Caswell and J. E. Finegan, 5 Beekman St., New York.

THE UNITED STATES NON-METALLIC MINERALS CORP., Los Angeles, Cal., has been incorporated with a capital of \$100,000, to manufacture refined mineral products. The incorporators are C. H. Dickinson, S. H. Deyot and H. J. O'Brien, 301 Brent Ave., South Pasadena, Cal.

THE POTASH-MARL CO., INC., Marlton, N. J., has been incorporated with a capital of \$50,000, to manufacture potash products. The incorporators are Harry T. Martin, George F. Pentecost and Stanley Sillman, all of Marlton.

HUNNELL & CO., INC., New York, N. Y., has been incorporated with a capital of \$25,000, to manufacture oils, chemicals, etc. The incorporators are L. C. Hunnell, G. A. and G. W. Heath, 136 Liberty St., New York.

THE WESTERN GYPSUM PRODUCTS CO., Los Angeles, Cal., has filed notice of organization to manufacture gypsum specialties. M. E. Edwards, 3433 Hollenbeck St., Los Angeles, represents the company.

THE COLUMBUS FERTILIZER CO., Columbus, Ga., has been incorporated with a capital of \$15,000, to manufacture commercial fertilizer products. The incorporators are O. C. and Drane Bullock, and C. M. Neal, all of Columbus.

THE C. A. REED CO., Williamsport, Pa., has been incorporated with a capital of \$303,000, to manufacture paper products. Construction of a new plant will be placed under way at once, to be located at Laurel and Willow Sts., and estimated to cost approximately \$160,000. Harry A. Miller is treasurer.

THE KEMOZONE LABORATORIES, INC., Buffalo, N. Y., has been incorporated with a capital of \$50,000, to manufacture chemicals and chemical byproducts. The incorporators are M. J. O., and O. F. Cabana, Buffalo. The company is represented by Norton Bros., Brisbane Bldg.

THE W. R. HOLLINGSHEAD CHEMICAL CO., New York, N. Y., has been incorporated under Delaware laws with a capital of \$1,000,000, to manufacture washing com-

pounds and other chemical products. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

THE R. & G. RUBBER CO., New York, N. Y., has been incorporated with a capital of \$5,000, to manufacture rubber products. The incorporators are S. Zimmerman, S. Klein and H. Booke. The company is represented by J. M. Wolf, 2 Rector St., New York.

THE NATIONAL GRAPHITE CO., Kittery, Me., has been incorporated with a capital of \$500,000, to manufacture graphite products. Dexter B. Pattison is president, and Horace Mitchell, treasurer, both of Kittery.

THE WESTMORELAND LIME PRODUCTS CO., Wilmington, Del., has been incorporated under state laws with capital of \$100,000, to manufacture lime and affiliated products. The company is represented by the Delaware Registration Trust Co., 900 Market St., Wilmington.

THE GLOBE FIBRE CO., New York, N. Y., has been incorporated with a capital of \$20,000, to manufacture fiber products. The incorporators are H. Silverman, K. Axelrod and Abraham Grometstein, 41 Park Row.

THE BANGOR PULP WOOD & LUMBER CO., Bangor, Me., has been incorporated with a capital of \$100,000, to manufacture pulp products. Arthur G. Anderson is president and treasurer, and Donald F. Snow, secretary, both of Bangor.

THE CARBONDALE MFG. CO., New York, N. Y., has been incorporated with a capital of \$200,000, to manufacture refined oil products. The incorporators are F. Schaefer, J. F. McDavitt and K. Drinane. The company is represented by Kaye, McDavitt & Scholer, 149 Broadway, New York.

THE STEAM BOILER MATERIAL CO., 718 West 63d St., Chicago, has been incorporated with a capital of \$15,000 to mine, manufacture and deal in products of fire clay, firebrick, furnace linings, etc. The incorporators are Charles A. Miller, Arthur T. Leafy and Charles Vlaricoates.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its seventy-fourth meeting at Toronto, Canada, Dec. 27 to 31, 1921.

AMERICAN CERAMIC SOCIETY will hold its twenty-first annual meeting at St. Louis, Feb. 27 to March 2, 1922.

AMERICAN GAS ASSOCIATION will hold its third annual convention in the Congress and Auditorium Hotels, Chicago, the week of Nov. 7. More than 100 manufacturers will exhibit their latest gas-burning appliances.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its annual winter meeting at Baltimore, Md., Dec. 6 to 9. Headquarters will be at the Southern Hotel and the sessions will be held in the Engineers' Club.

AMERICAN MINING CONGRESS AND NATIONAL EXPOSITION OF MINES AND MINING EQUIPMENT will hold its twenty-fourth annual convention in the Coliseum, Chicago, Oct. 17 to 22.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS will hold its thirty-eighth annual convention at the Washington Hotel, Washington, D. C., Oct. 24-26.

INDUSTRIAL COST ASSOCIATION will hold its second national conference at Pittsburgh, Pa., Nov. 2-4, with headquarters at the William Penn Hotel.

INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA will hold its annual convention at the Waldorf-Astoria, New York, Nov. 1-5.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Oct. 14—Société de Chimie Industrielle, regular meeting; Oct. 21—Society of Chemical Industry, Grasselli Medal; Nov. 11—American Chemical Society (in charge), Society of Chemical Industry, American Electrochemical Society, Société de Chimie Industrielle, joint meeting; Nov. 18—American Electrochemical Society, regular meeting; Dec. 2—Society of Chemical Industry, regular meeting; Dec. 9—American Chemical Society, regular meeting.